BLM LIBRARY
88045169

U.S. Department of the Interior
Bureau of Land Management

Spokane District Office
1103 N. Fancher
Spokane, Washington 99212-1275

October 1994

Final Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion

TN
413
.W2
S65
1994

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

BLM LIBRARY
RS 150A BLDG. 50
DENVER FEDERAL CENTER
P.O. BOX 25047
DENVER, CO 80225

BLM/OR/WA/PL-94-26+1792

ID 88045169

TN
413
.W2
S65
1994

U. S. Department of the Interior
Bureau of Land Management

Final

Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion

October, 1994

BLM LIBRARY
RS 150A BLDG. 50
DENVER FEDERAL CENTER
P.O. BOX 25047
DENVER, CO 80225

Border Resource Area Manager

10/19/94
Date

MARCH 3, 1849

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Spokane District Office
1103 N. Fancher
Spokane, Washington 99212-1275

IN REPLY REFER TO:

(509) 536-1200

WMP130 89-019B
3809 (135)

Dear Reader:

Enclosed for your review and comment is the Final Lamefoot Mine Environmental Impact Statement Supplement (EISS) to the Kettle River Key Project Expansion FEIS. This document and the Draft EISS were prepared by BLM with the assistance of Ferry County, participating as a cooperating party, and Woodward-Clyde Consultants.

Over 200 copies of the Draft were mailed out to the general public and other interested parties. In addition, one public meeting was held during the comment period. Over all, a total of 23 individual responses were received. These comments have been printed in their entirety along with BLM's responses.

This EISS will be available for a 30 day review period. Any comments you may have should be directed to me, Ann Aldrich Border Resource Area Manager, Spokane District, 1103 North Fancher, Spokane, WA 99212-1275. Thank you for your involvement.

Sincerely yours,

Ann B. Aldrich
Border Resource Area Manager

LAMEFOOT PROJECT DRAFT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT

DRAFT ( ) FINAL (X) EIS SUPPLEMENT
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

1. Type of Action: Administrative (x) Legislative ( )

2. Abstract: The proposed Lamefoot Mine project consists of extracting ore by a long hole open stoping mining technique, loading the ore into underground trucks and transporting it to the surface where it will be hauled to the Key Mill via state and county roads. The ore will be processed by the conventional carbon-in-leach method. The processed ore will be stored at an existing tailings impoundment located on private land.

Waste rock will be deposited in temporary waste storage piles at the Lamefoot site. Upon completion of the commercial mining phase, the waste rock will be hauled underground and used as backfill to provide ground support and mitigate potential for acid formation.

Reclamation plans include the use of topsoil and fertilization, if necessary, to revegetate areas of surface disturbance, erosion and sediment control until revegetation has been successfully established, and upon completion of mining activities, managing the land for wildlife habitat.

Alternative 1 is the No Action Alternative under which Echo Bay would not receive approval to develop the Lamefoot Project and would be required to carry out reclamation in accordance with the conditions specified in the approved Exploration Plan of Operations.

Alternative 2 is an alternate method for introducing backfill materials to the underground workings. Drop passes at the base of the backfill borrow area would allow underground access to the workings without crossing the Wolfe Camp Road.

Alternative 3 is an alternate ore transportation route utilizing Highway 21 and the Fish Hatchery Road. This route would provide a shorter haul distance than the proposed Old Kettle Falls Road (formerly the Cooke Mountain Road) route.

Alternative 4 - Alternate Sub-County Road Access for Backfill. This alternative would eliminate traffic control and safety concerns associated with mine traffic crossing the Wolfe Camp Road, and would also eliminate concerns relating to poor rock quality and infiltration of groundwater associated with the subsurface, cross valley access ramp.

Alternative 5 - Partial Mine Development. This alternative is the same as Alternative 1, Proposed Action except that mining would be limited to only that portion of the ore body located above the predicted post closure water table (i.e. 2,750 foot msl).

Alternative 6 - Limited mining Alternative - 2741 Foot Level

Alternative 6 is a mining alternative that is the same design as Alternative 5 except it incorporates the existing floor elevation of Zone 3 at the 2741 foot level.
The public review/protest period will be for 30 days ending November 28, 1994.

For further information contact:

Ann B. Aldrich, Border Resource Area Manager
Bureau of Land Management
Spokane District Office
1103 E. Fancher Way
Spokane, WA 99212-1275

TABLE OF CONTENTS

Section Page

SUBJECT INDEX I-1

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1

1.1 GEOGRAPHIC SETTING 1-1
1.2 PROJECT AREA AND OWNERSHIP 1-1
1.3 PURPOSE AND NEED 1-1
1.4 HISTORICAL BACKGROUND 1-2
1.5 EIS SUPPLEMENT PROCESS 1-2
1.6 SCOPING ISSUES 1-3
1.7 RELATIONSHIP TO BLM POLICIES, PLANS AND PROGRAMS 1-3
1.8 OTHER PERMITS AND APPROVALS 1-4

2.0 PROPOSED ACTION AND ALTERNATIVES 2-1

2.1 OVERVIEW 2-1
2.2 ALTERNATIVES INCLUDED AND ELIMINATED 2-1

2.2.1 Alternatives Considered 2-1
2.2.2 Eliminated Alternatives 2-2
2.2.3 Alternatives Included in the EISS 2-3

2.3 PROPOSED ACTION 2-4

2.3.1 General 2-4
2.3.2 Project Schedule 2-5
2.3.3 Underground Mining 2-6
2.3.4 Additional Geochemical Characterization Program for Backfill and Wall Rock 2-9
2.3.5 Water Control, Monitoring, and Treatment 2-10
2.3.6 Power/Water Requirements 2-17
2.3.7 Waste Rock Disposal Area 2-17
2.3.8 Ore Transportation 2-18
2.3.9 County Road Relocation 2-18
2.3.10 Reclamation 2-19
2.3.11 Exploration Activities 2-19

2.4 DESCRIPTION OF ALTERNATIVES 2-21

2.4.1 Alternative 1 - No Action 2-21
2.4.2 Alternative 2 - Alternative Drop Pass Access for Backfill 2-21
2.4.3 Alternative 3 - Alternative Ore Transportation Route (State Highway 21 and Fish Hatchery Road) 2-22
2.4.4 Alternative 4 - Alternative Sub-County Road Access for Backfill 2-22

Section Page

2.4.5 Alternative 5 - Limited Mine Development - 2,750' Level 2-23
2.4.6 Alternative 6 - Limited Mining Alternative - 2,741' Level 2-27

2.5 COMPARISON OF ALTERNATIVES 2-27

3.0 AFFECTED ENVIRONMENT 3-1

3.1 GROUNDWATER 3-1

3.1.1 Study Area 3-1
3.1.2 Baseline Conditions Prior to 1992 3-1
3.1.3 Baseline Conditions 1992-1993 3-2
3.1.4 Mill and Tailing Facility 1989-present 3-4

3.2 SURFACE WATER 3-5

3.2.1 Study Area 3-5
3.2.2 Baseline Conditions Prior to 1992 3-5
3.2.3 Baseline Conditions 1992-1993 3-6
3.2.4 Hydrologic Analysis 3-7

3.3 GEOCHEMISTRY 3-8

3.3.1 Study Area 3-8
3.3.2 Baseline Conditions Prior to 1992 3-8
3.3.3 Baseline Conditions 1992-1993 3-10

3.4 GEOLOGY AND SUBSIDENCE 3-14

3.4.1 Study Area 3-14
3.4.2 Baseline Conditions Prior to 1992 3-17
3.4.3 Subsidence Potential from 1992-93 Exploration Program 3-17

3.5 AESTHETIC RESOURCES 3-18

3.5.1 Study Area 3-18
3.5.2 Baseline Conditions Prior to 1992 3-18
3.5.3 Baseline Conditions 1992-1993 3-19

3.6 TRANSPORTATION 3-21

3.6.1 Study Area 3-21
3.6.2 Baseline Conditions Prior to 1992 3-21
3.6.3 Exploration Activities 3-21

Section Page

3.7 NOISE 3-23

3.7.1 Study Area 3-23
3.7.2 Baseline Noise Conditions 3-25
3.7.3 Noise from Exploration Activities and Mill Operations 3-25

3.8 SOILS AND RECLAMATION 3-26

3.8.1 General Conditions Prior to Exploration 3-26
3.8.2 Baseline Conditions 3-27
3.8.3 Current Status of Exploration and Mill Operations 3-28

3.9 AIR RESOURCES 3-29

3.9.1 Study Area 3-29
3.9.2 Baseline Air Resources Conditions 3-29
3.9.3 Exploration Activities 3-30

3.10 RECREATION 3-30

3.10.1 Study Area 3-30
3.10.2 Baseline Conditions (Pre-1992) 3-31
3.10.3 Exploration Activities (1992-1993) 3-31

3.11 SOCIOECONOMICS 3-32

3.11.1 Study Area 3-32
3.11.2 Baseline Conditions Prior to 1992 3-32
3.11.3 Baseline Conditions During Exploration Activities 3-33

3.12 CULTURAL RESOURCES 3-34

3.12.1 Study Area 3-34
3.12.2 Baseline Conditions 3-35

3.13 VEGETATION 3-35

3.13.1 Study Area 3-35
3.13.2 Baseline Conditions Prior to June 1992 3-36
3.13.3 Baseline Conditions After Lamefoot Exploration (after June 1992) 3-38

3.14 WILDLIFE 3-39

3.14.1 Study Area 3-39
3.14.2 Baseline Conditions Prior to June 1992 3-39
3.14.3 Baseline Conditions After Lamefoot Exploration (after June 1992) 3-41

Section Page

4.0 ENVIRONMENTAL CONSEQUENCES 4-1

IMPACT METHODOLOGY 4-1

4.1 GROUNDWATER 4-1

4.1.1 No Action 4-1
4.1.2 Proposed Action 4-2
4.1.3 Alternate Backfill Access 4-6
4.1.4 Alternate Haul Route 4-6
4.1.5 Alternate Sub-County Road Backfill Access 4-6
4.1.6 Limited Mine Development - 2750' Level 4-6
4.1.7 Limited Mine Development - 2741' Level 4-7
4.1.8 Mill and Tailings Facility 4-7

4.2 SURFACE WATER 4-8

4.2.1 No Action 4-8
4.2.2 Proposed Action 4-8
4.2.3 Alternate Backfill 4-9
4.2.4 Alternate Haul Route 4-9
4.2.5 Alternate Sub-County Road Backfill Access 4-9
4.2.6 Limited Mine Development - 2750' Level 4-9
4.2.7 Limited Mine Development - 2741' Level 4-10
4.2.8 Mill and Tailings Facility 4-10

4.3 GEOCHEMISTRY 4-10

4.3.1 No Action 4-10
4.3.2 Proposed Action 4-10
4.3.3 Alternate Drop Pass Backfill Access 4-15
4.3.4 Alternate Haul Route 4-16
4.3.5 Alternate Sub-County Road Access for Backfill 4-16
4.3.6 Limited Mine Development - 2750' Level 4-16
4.3.7 Limited Mine Development - 2741' Level 4-17
4.3.8 Mill and Tailings Facility 4-17

4.4 GEOLOGY AND SUBSIDENCE 4-18

4.4.1 No Action 4-18
4.4.2 Proposed Action 4-18
4.4.3 Alternative Backfill Access 4-20
4.4.4 Alternate Haul Routes 4-20
4.4.5 Alternate Sub-County Road Backfill Access 4-21
4.4.6 Limited Mine Development - 2750' Level 4-21
4.4.7 Limited Mine Development - 2741' Level 4-21
4.4.8 Mill and Tailings 4-21

Section Page

4.5 AESTHETIC RESOURCES 4-21

4.5.1 Impact Methodology 4-21
4.5.2 No Action 4-22
4.5.3 Proposed Action 4-22
4.5.4 Alternative Backfill Method 4-23
4.5.5 Alternative Haul Route 4-23
4.5.6 Alternate Sub-County Road Backfill Access 4-23
4.5.7 Limited Mine Development - 2750' Level 4-23
4.5.8 Limited Mine Development - 2741' Level 4-23
4.5.9 Mill and Tailings 4-24

4.6 TRANSPORTATION 4-24

4.6.1 No Action 4-24
4.6.2 Proposed Action 4-24
4.6.3 Alternate Backfill Method 4-25
4.6.4 Alternative Haul Route 4-25
4.6.5 Alternate Sub-County Road Backfill Access 4-26
4.6.6 Limited Mine Development - 2750' Level 4-26
4.6.7 Limited Mine Development - 2741' Level 4-26
4.6.8 Mill and Tailings 4-26

4.7 NOISE 4-26

4.7.1 No Action 4-27
4.7.2 Proposed Action 4-27
4.7.3 Alternative Backfill 4-28
4.7.4 Alternative Haul Route 4-28
4.7.5 Alternate Sub-County Road Backfill Access 4-28
4.7.6 Limited Mine Development - 2750' Level 4-28
4.7.7 Limited Mine Development - 2741' Level 4-28
4.7.8 Mill and Tailings 4-28

4.8 SOILS AND RECLAMATION POTENTIAL 4-28

4.8.1 No Action 4-28
4.8.2 Proposed Action 4-29
4.8.3 Alternative Backfill 4-30
4.8.4 Alternative Haul Route 4-30
4.8.5 Alternate Sub-County Road Backfill Access 4-30
4.8.6 Limited Mine Development - 2750' Level 4-30
4.8.7 Limited Mine Development - 2741' Level 4-30
4.8.8 Mill and Tailing Disposal Facilities 4-30

Section Page

4.9 AIR RESOURCES 4-31

4.9.1 No Action 4-31
4.9.2 Proposed Action 4-31
4.9.3 Alternative Backfill 4-32
4.9.4 Alternative Haul Route 4-32
4.9.5 Alternate Sub-County Road Backfill Access 4-32
4.9.6 Limited Mine Development - 2750' Level 4-32
4.9.7 Limited Mine Development - 2741' Level 4-32
4.9.8 Mill and Tailings 4-32

4.10 RECREATION 4-32

4.10.1 Impact Methodology 4-32
4.10.2 No Action 4-33
4.10.3 Proposed Action 4-33
4.10.4 Alternative Backfill Method 4-33
4.10.5 Alternative Haul Route 4-33
4.10.6 Alternate Sub-County Road Backfill Access 4-33
4.10.7 Limited Mine Development - 2750' Level 4-34
4.10.8 Limited Mine Development - 2741' Level 4-34
4.10.9 Mill and Tailings 4-34

4.11 SOCIOECONOMICS 4-34

4.11.1 No Action 4-34
4.11.2 Proposed Action 4-35
4.11.3 Alternative Backfill Methods 4-37
4.11.4 Alternative Haul Route 4-37
4.11.5 Alternate Sub-County Road Backfill Access 4-37
4.11.6 Limited Mine Development - 2750' Level 4-38
4.11.7 Limited Mine Development - 2741' Level 4-38
4.11.8 Mill and Tailings 4-39

4.12 CULTURAL RESOURCES 4-39

4.12.1 No Action 4-39
4.12.2 Proposed Action 4-39
4.12.3 Alternative Backfilling 4-39
4.12.4 Alternative Haul Route 4-39
4.12.5 Alternate Sub-County Road Backfill Access 4-39
4.12.6 Limited Mine Development - 2750' Level 4-40
4.12.7 Limited Mine Development - 2741' Level 4-40

Section Page

4.13 VEGETATION 4-40

4.13.1 Impact Methodology 4-40
4.13.2 No Action Alternative 4-40
4.13.3 Proposed Action 4-40
4.13.4 Alternative Backfill Method 4-41
4.13.5 Alternative Haul Route 4-41
4.13.6 Alternate Sub-County Road Backfill Access 4-41
4.13.7 Limited Mine Development - 2750' Level 4-41
4.13.8 Limited Mine Development - 2741' Level 4-41
4.13.9 Mill and Tailings 4-41

4.14 WILDLIFE 4-41

4.14.1 Impact Methodology 4-41
4.14.2 No Action 4-42
4.14.3 Proposed Action 4-42
4.14.4 Alternative Backfill Method 4-42
4.14.5 Alternative Haul Route 4-43
4.14.6 Alternate Sub-County Road Backfill Access 4-43
4.14.7 Limited Mine Development - 2750' Level 4-43
4.14.8 Limited Mine Development - 2741' Level 4-43
4.14.9 Mill and Tailings 4-43

4.15 CUMULATIVE IMPACTS 4-43

4.15.1 Groundwater 4-47
4.15.2 Surface Water 4-48
4.15.3 Geochemistry 4-48
4.15.4 Geology and Subsidence 4-48
4.15.5 Aesthetic Resources 4-49
4.15.6 Transportation 4-49
4.15.7 Noise 4-50
4.15.8 Soils 4-50
4.15.9 Air Quality 4-50
4.15.10 Recreation 4-51
4.15.11 Socioeconomics 4-51
4.15.12 Cultural Resources 4-52
4.15.13 Vegetation 4-53
4.15.14 Wildlife 4-53

4.16 RECOMMENDED MITIGATION 4-54

4.16.1 Groundwater 4-54
4.16.2 Surface Water 4-54
4.16.3 Geochemistry 4-55
4.16.4 Geology and Subsidence 4-56
4.16.5 Aesthetic Resources 4-57

Section Page

4.16.6 Transportation 4-58
4.16.7 Noise 4-58
4.16.8 Soils and Reclamation Potential 4-59
4.16.9 Air Quality and Meteorology 4-59
4.16.10 Recreation 4-59
4.16.11 Socioeconomics 4-59
4.16.12 Cultural Resources 4-59
4.16.13 Vegetation 4-60
4.16.14 Wildlife 4-60

5.0 OTHER EISS PROCEDURAL ISSUES 5-1

5.1 UNAVOIDABLE ADVERSE IMPACTS 5-1

5.1.1 Groundwater 5-1
5.1.2 Surface Water 5-1
5.1.3 Geochemistry 5-1
5.1.4 Geology and Subsidence 5-1
5.1.5 Aesthetic and Visual Resources 5-1
5.1.6 Transportation 5-1
5.1.7 Noise Levels 5-1
5.1.8 Soils 5-2
5.1.9 Air Quality and Meteorology 5-2
5.1.10 Recreation 5-2
5.1.11 Socioeconomics 5-2
5.1.12 Cultural Resources 5-2
5.1.13 Vegetation 5-2
5.1.14 Wildlife 5-2

5.2 SHORT-TERM USES VS. LONG-TERM PRODUCTIVITY 5-2

5.2.1 Groundwater 5-2
5.2.2 Surface Water 5-3
5.2.3 Geochemistry 5-3
5.2.4 Geology and Subsidence 5-3
5.2.5 Aesthetic and Visual Resources 5-3
5.2.6 Transportation 5-3
5.2.7 Noise Levels 5-3
5.2.8 Soils 5-3
5.2.9 Air Quality and Meteorology 5-3
5.2.10 Recreation 5-3
5.2.11 Socioeconomics 5-3
5.2.12 Cultural Resources 5-3
5.2.13 Vegetation 5-4
5.2.14 Wildlife 5-4

Section Page

5.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES 5-4

5.3.1 Groundwater 5-4
5.3.2 Surface Water 5-4
5.3.3 Geochemistry 5-4
5.3.4 Geology and Subsidence 5-4
5.3.5 Aesthetic and Visual Resources 5-4
5.3.6 Transportation 5-4
5.3.7 Noise Levels 5-4
5.3.8 Soils 5-5
5.3.9 Air Quality and Meteorology 5-5
5.3.10 Recreation 5-5
5.3.11 Socioeconomics 5-5
5.3.12 Cultural Resources 5-5
5.3.13 Vegetation 5-5
5.3.14 Wildlife 5-5

6.0 CONSULTATION AND COORDINATION 6-1

6.1 PUBLIC PARTICIPATION 6-1
6.2 PUBLIC COMMENTORS 6-1
6.3 AGENCIES AND ORGANIZATIONS CONSULTED 6-2

6.3.1 Federal Agencies 6-2
6.3.2 State Agencies 6-2
6.3.3 Local Agencies 6-2

6.4 COMMENT ANALYSIS 6-2
6.5 DEISS DISTRIBUTION AND REVIEW 6-6

7.0 LIST OF PREPARERS 7-1

8.0 REFERENCES 8-1

LIST OF APPENDIXES

APPENDIX A WATER TREATMENT OPTIONS
APPENDIX B 1992-1993 GEOCHEMISTRY REPORT AND MONITOR WELL DATA
APPENDIX B-1 LAMEFOOT GEOCHEMISTRY REPORT ECHO BAY MINERALS, AUGUST 1993
APPENDIX B-2 MONITOR WELL DATA APPROXIMATELY APRIL 1992 THROUGH NOVEMBER 1993
APPENDIX C GEOCHEMISTRY AND WATER QUALITY
APPENDIX C-1 GEOCHEMISTRY DATA TABLES AND KINETIC TEST DATA
APPENDIX C-2 WATER QUALITY MONITORING DATA - LF-1, LF-2, LF-I SPREADSHEETS
APPENDIX C-3 INTERPRETATION OF WATER QUALITY
APPENDIX D SUBSIDENCE EFFECTS
APPENDIX E RECLAMATION PLAN

Following Page

LIST OF TABLES

TABLE S-1 SUMMARY OF LONG-TERM ENVIRONMENTAL CONSEQUENCES AND COMPARISON OF ALTERNATIVES ES-3

TABLE 1-1 OTHER PERMITS AND APPROVALS 1-4

TABLE 2-1 ALTERNATIVES CONSIDERED FOR LAMEFOOT EISS 2-1
TABLE 2-2 LAMEFOOT EISS - ALTERNATIVES SUMMARY 2-3
TABLE 2-3 PROJECT RELATED WATER PRODUCTION AND USE 2-10
TABLE 2-4 LAMEFOOT MINE HYDROLOGIC MONITORING PROGRAM DURING OPERATIONS 2-11
TABLE 2-5 PARAMETERS AND ANALYTICAL METHODS FOR WATER (METALS) 2-11
TABLE 2-6
TABLE 2-7 LAMEFOOT MINE PLANNED POST-CLOSURE HYDROLOGIC MONITORING PROGRAM 2-11
TABLE 2-8 KETTLE RIVER MINES PRODUCTION AND KEY MILL TAILINGS CAPACITY 2-18
TABLE 2-9 SUMMARY OF LONG-TERM ENVIRONMENTAL CONSEQUENCES AND COMPARISON OF ALTERNATIVES 2-27

TABLE 3.1-1 WATER WELL INFORMATION FOR THE LAMEFOOT STUDY AREA 3-2
TABLE 3.1-2 BACKGROUND WATER QUALITY USING LF-1 AND LF-2 LAMEFOOT PROJECT VICINITY 3-3
TABLE 3.3-1A WATER QUALITY ANALYTICAL RESULTS OF SAMPLES COLLECTED DURING MARCH 1993 UNDERGROUND HYDROGEOLOGIC SURVEY 3-9
TABLE 3.3-1 WATER QUALITY ANALYTICAL RESULTS OF SAMPLES COLLECTED DURING MARCH 1993 UNDERGROUND HYDROGEOLOGIC SURVEY 3-9
TABLE 3.3-2 SUMMARY OF COMPOSITE SAMPLES SUBMITTED FOR KINETIC TESTING FOR ACID BASE ACCOUNTING ANALYSIS 3-11
TABLE 3.3-3 EVALUATION CRITERIA FOR THE LAMEFOOT ACID-BASE ACCOUNTING ANALYSES 3-11
TABLE 3.3-4 ABA RESULTS FOR THE WASTE/MINE WALL ROCK SAMPLES RELATIVE TO THE EVALUATION CRITERIA 3-12
TABLE 3.3-5 SUMMARY OF ACID-BASE ACCOUNTING RESULTS OF MINE WALL ROCK SAMPLES 3-12
TABLE 3.3-6 SUMMARY OF QUARRY BACKFILL SAMPLES RELATIVE TO EVALUATION CRITERIA 3-12
TABLE 3.3-7 SUMMARY OF ACID-BASE ACCOUNTING RESULTS OF BACKFILL QUARRY SAMPLES 3-13
TABLE 3.5-1 VISUAL RESOURCE MANAGEMENT OBJECTIVES 3-19
TABLE 3.7-1 RESULTS OF LAMEFOOT PROJECT NOISE SURVEY, MARCH 1993 3-26

Following Page

TABLE 3.8-1 APPROXIMATE SOIL PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SOILS OF LPA WITH COVERSOIL RATING 3-27
TABLE 3.8-2 SOIL MATERIAL SUITABILITY CRITERIA FOR SALVAGE AND REDISTRIBUTION AS COVERSOIL 3-27
TABLE 3.8-3 AREAS OF DISTURBANCE, LAMEFOOT PROJECT 3-27
TABLE 3.8-4 TEST RESULTS FOR STOCKPILE MATERIAL 3-28
TABLE 3.9-1 SUMMARY OF AMBIENT AIR QUALITY STANDARDS FOR CRITERIA POLLUTANTS 3-30
TABLE 3.11-1 AGE DISTRIBUTION IN FERRY COUNTY, WASHINGTON 3-32
TABLE 3.11-2 1991 POPULATION DISTRIBUTION BY ETHNIC GROUP 3-32
TABLE 3.11-3 FERRY COUNTY EMPLOYMENT BY SECTOR, 1986 AND 1991 3-32
TABLE 3.11-4 FERRY COUNTY EARNINGS BY ECONOMIC SECTOR, 1986 AND 1991 3-32
TABLE 3.14-1 SUMMARY OF THE OCCURRENCE AND STATUS OF SENSITIVE, RARE, THREATENED, AND ENDANGERED WILDLIFE SPECIES IN THE PROPOSED LAMEFOOT PROJECT AREA 3-41

TABLE 4.1-1 MINE INFLOW ESTIMATES 4-2
TABLE 4.4-1 MAXIMUM VOID HEIGHT FOR PLANNED UPPER LAMEFOOT STOPES AFTER BACKFILLING 4-20
TABLE 4.9-1 AIR QUALITY SUMMARY OF EMISSIONS 4-31
TABLE 4.15-1 CUMULATIVE SOCIOECONOMIC IMPACTS FOR THE LAMEFOOT PROJECT 4-51
TABLE 4.15-2 HISTORIC SITES LOCATED BY MINE 4-52

Following Page

LIST OF FIGURES

FIGURE 1-1 GENERAL LOCATION MAP 1-1
FIGURE 1-2 LAMEFOOT PROJECT SITE ACCESS AND REGIONAL TOPOGRAPHY 1-1
FIGURE 1-3 LAND OWNERSHIP AND CLAIMBLOCK BOUNDARIES 1-1
FIGURE 2-1 CONCEPTUAL LAYOUT FOR OPEN PIT ALTERNATIVE 2-2
FIGURE 2-2 SITE TOPOGRAPHY SHOWING EXISTING DRILL ROADS, FACILITIES AND EXPLORATION/DEVELOPMENT WORKINGS 2-4
FIGURE 2-3 OBLIQUE VIEW OF UNDERGROUND EXPLORATION AND COMMERCIAL DEVELOPMENT PROGRAM 2-4
FIGURE 2-4 KEY MILL AND TAILING POND FACILITY LAYOUT 2-4
FIGURE 2-5 KEY MILL TAILING POND GEOLOGIC CROSS SECTION B-B' 2-4
FIGURE 2-6 FACILITY LAYOUT 2-4
FIGURE 2-7 CONCEPTUAL PROPOSED DIVERSION OF WOLFE CAMP ROAD 2-5
FIGURE 2-8 GENERALIZED CROSS SECTION OF LAMEFOOT AREA SHOWING BACKFILLED STOPE AND ROAD RELOCATION EXCAVATION 2-5
FIGURE 2-9 MINING SEQUENCE 2-5
FIGURE 2-10 MINE DECLINE DEVELOPMENT TECHNIQUES 2-5
FIGURE 2-11 CONCEPTUAL DIAGRAM OF SUBLEVEL STOPING WITH LONG-HOLE AND RING DRILLING AND BLASTING METHODS 2-6
FIGURE 2-12 STOPING AND BACKFILLING METHODS 2-6
FIGURE 2-13 OBLIQUE VIEW OF UNDERGROUND PHASE I EXPLORATION/ DEVELOPMENT PROGRAM 2-6
FIGURE 2-14 OBLIQUE VIEW OF UNDERGROUND PHASE II EXPLORATION/ DEVELOPMENT PROGRAM 2-10
FIGURE 2-14a WATER WELL INVENTORY MAP 2-10
FIGURE 2-14b LAMEFOOT MINE WATER QUALITY MONITORING BY YEAR 2-12
FIGURE 2-14c LAMEFOOT MINE PROJECT SCHEDULE 2-12
FIGURE 2-15 OBLIQUE VIEW OF UNDERGROUND PHASE II PROGRAM ON BLM LAND 2-20
FIGURE 2-16 ALTERNATE BACKFILL ACCESS MAP 2-20
FIGURE 2-17 CONCEPTUAL PROPOSED LAMEFOOT ROCK FILL ASSEMBLY 2-20
FIGURE 2-18 ALTERNATE BACKFILL ACCESS MAP 2-21
FIGURE 2-19 CONCEPTUAL PROPOSED ALTERNATIVE WASTE ROCK BACKFILL ASSEMBLY LOOKING SOUTH 2-21
FIGURE 2-20 LAMEFOOT MINE SECTION 27,400 N PROPOSED BACKFILL HAUL 2-22
FIGURE 2-21 LAMEFOOT PROJECT CEMENTED ROCKFILL PLANT CONCEPTUAL LAYOUT 2-22
FIGURE 2-22 LAMEFOOT PROJECT BACKFILL QUARRY AND COUNTY ROAD DIVERSION SUB-COUNTY ROAD BACKFILL ACCESS 2-22
FIGURE 2-23 MINE WORKINGS ABOVE THE 2750' ELEVATION 2-23
FIGURE 2-24 EXISTING WORKINGS AND PLAN FOR NEW WORKINGS - 2745 NORTH DRIFT 2-23
FIGURE 2-25 ROADSIDE INTERCEPTION DITCH PLAN VIEW 2-25
FIGURE 2-26 LONG SECTION 2750' MINING ZONES 2-27
FIGURE 3.1-1 ELEVATIONS OF SPRING, WETLANDS, AND PIEZOMETRIC HEADS IN WELLS 3-1

Following Page

FIGURE 3.1-2 TRILINEAR DIAGRAM SHOWING COMPARISON OF GROUNDWATER CHEMISTRY 3-3
FIGURE 3.3-1 GEOLOGIC CROSS SECTION ILLUSTRATING THE DISTRIBUTION OF WASTE ROCK LITHOLOGIES 3-8
FIGURE 3.3-2 GEOLOGIC CROSS SECTION ILLUSTRATING THE DISTRIBUTION OF WASTE ROCK LITHOLOGIES 3-8
FIGURE 3.3-2A GEOLOGIC CROSS SECTION 27,400 NORTH 3-8
FIGURE 3.3-3 ESTIMATED WASTE ROCK PERCENTAGES 3-9
FIGURE 3.3-4 IDENTIFICATION OF ACID-FORMING AND NON-ACID FORMING SAMPLES BASED ON ACID-BASED ACCOUNT TEST RESULTS 3-11
FIGURE 3.3-5 WASTE AND MINE WALL ROCK GEOCHEMICAL SAMPLING LOCATION MAP 3-12
FIGURE 3.3-6 LOCATION MAP OF BACKFILL EXPLORATION HOLES 3-12
FIGURE 3.4-1 GEOLOGIC MAP OF LAMEFOOT PROJECT VICINITY 3-15
FIGURE 3.5-1 TOPOGRAPHIC VISIBILITY AND VRM CLASSIFICATIONS 3-19
FIGURE 3.7-1 LAMEFOOT PROJECT NOISE MONITORING LOCATIONS 3-25
FIGURE 3.8-1 SOILS MAP OF LAMEFOOT PROJECT VICINITY 3-27
FIGURE 3.12-1 AREAS SURVEYED FOR CULTURAL RESOURCES 3-35
FIGURE 3.13-1 MAP SHOWING VEGETATION TYPES IN PROJECT AREA 3-35
FIGURE 3.14-1 WILDLIFE STUDY AREA 3-39
FIGURE 4.4-1 PREDICTED CHIMNEY COLLAPSE GEOMETRY FOR EXAMPLE CASE 4-20
FIGURE 4.15-1 GENERAL CUMULATIVE IMPACTS STUDY AREA WITH MAJOR REGIONAL LANDMARKS AND ACTIVITY CENTERS 4-43
FIGURE 4.16-1 CONCEPTUAL DRAWING, POST-CLOSURE UNDERGROUND WATER QUALITY MITIGATION MEASURES 4-55
FIGURE 4.16-2 EXAMPLES OF POTENTIAL CROWN PILLAR FAILURE MECHANISMS 4-57

SUBJECT INDEX

Aesthetic Resources 3-18, 4-21, 4-49, 4-54, 5-1, 5-3, 5-4
Air 3-29, 4-31, 4-50, 4-59, 5-2, 5-3, 5-5
Alternatives ES-1, 2-1
Coordination and Consistency 1-3, 7-1
Cultural Resources 3-34, 4-39, 4-51, 4-59, 5-2, 5-3, 5-5
Cumulative Impacts 4-33
Geochemistry 3-8, 4-10, 4-48, 4-55, 5-1, 5-3, 5-4
Geology 3-14, 4-18, 4-48, 4-55, 5-1, 5-3, 5-4
Groundwater 3-1, 4-1, 4-47, 4-54, 5-1, 5-2, 5-4
Issues 1-3, 7-2
Land Ownership 1-1, 2-5, 3-25, 3-33, 4-22
Mining Methods 2-2, 2-3
Noise 3-23, 4-26, 4-50, 4-58, 5-1, 5-3, 5-4
Permits 1-3
Reclamation 3-26, 4-28, 4-59
Recreation 3-30, 4-32, 4-51, 4-59, 5-2, 5-3, 5-5
Socioeconomics 3-32, 4-34, 4-49, 4-51, 4-59, 5-2, 5-3, 5-5
Soils 3-26, 4-28, 4-50, 4-59, 5-2, 5-3, 5-5
Special Status Species
  Animals 3-41, 3-42
  Plants 3-38
Subsidence 3-14, 4-18, 4-48, 4-56, 5-1, 5-3, 5-4
Surface Water 3-5, 4-8, 4-48, 4-54, 5-1, 5-3, 5-4
Transportation 3-21, 4-24, 4-49, 4-58, 5-1, 5-3, 5-4
Vegetation 3-35, 4-40, 4-53, 4-60, 5-2, 5-4, 5-5
Water Treatment 2-10
Wetlands 3-2, 3-6, 3-37, 3-38, 4-7
Wildlife 3-39, 4-41, 4-53, 4-60, 5-2, 5-4, 5-5

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This Environmental Impact Statement Supplement (EISS) describes an evaluation of a proposal by Echo Bay Minerals, Inc. to develop the Lamefoot underground gold mine in northern Ferry County, Washington. This summary of the EISS contains a description of the mine plan, the affected environment, potential impacts of the mine upon the environment, and alternatives to the proposed action.

DESCRIPTION OF PROPOSED ACTION

The proposed Lamefoot Mine project consists of extracting ore by a long hole open stoping mining technique, loading the ore into underground trucks and transporting it to the surface where it will be hauled to the Key Mill via state and county roads. The ore will be processed by the conventional carbon-in-leach method. The processed ore will be stored at an existing tailings impoundment located on private land.

Waste rock will be deposited in temporary waste storage piles at the Lamefoot site. Upon completion of the commercial mining phase, the waste rock will be hauled underground and used as backfill to provide ground support and mitigate potential for acid formation. Additional backfill will be quarried from a site adjacent to the mine in the Wolfe Camp drainage, and hauled across Wolfe Camp Road to the mine workings.

Reclamation plans include the use of topsoil and fertilization, if necessary, to revegetate areas of surface disturbance, erosion and sediment control until revegetation has been successfully established and, upon completion of mining activities, managing the land for wildlife habitat.

DEVELOPMENT OF ALTERNATIVES

The BLM completed a scoping process to solicit comments from the public and other concerned parties and, based on the comments received, developed and refined several alternatives for further evaluation. Alternatives to the Proposed Action include two alternative backfill methods, an alternative ore transport route, and the no action alternative and two limited mining alternatives. All reasonable alternatives were considered and evaluated for their potential environmental impacts, including impacts to air, water, soil, vegetation, wildlife, and the human environment. The alternatives were also evaluated on engineering factors. Alternatives considered but eliminated from further analysis included open pit mining, open stope mining without backfilling, open stope mining leaving pillars, and a dedicated transport route. The alternatives selected for further consideration are discussed below.

ALTERNATIVES EVALUATED

Alternative 1 - No Action

The No Action Alternative, under which Echo Bay would not receive approval to develop the Lamefoot Project, and would be required to carry out reclamation in accordance with the conditions specified in the approved Exploration Plan of Operations. Surface disturbance associated with the exploration/development program and existing surface facilities would not be increased.

Alternative 2 - Alternate Drop Pass Backfill Access Method

Alternative 2 is an alternate method for introducing backfill materials to the underground workings. Drop passes at the base of the Wolfe Camp quarry backfill borrow area would allow underground access to the workings without crossing the Wolfe Camp Road. Front end loaders would dump backfill materials into the drop pass, by a grated loading chute, and into a truck. Following truck loading, backfill materials would be hauled via an access ramp to the underground workings and placed as described in the Proposed Action.

Alternative 3 - Alternate Ore Transportation Route

Alternative 3 is an alternate ore transportation route utilizing Highway 21 and the Fish Hatchery Road. This route would provide a shorter haul distance than the proposed Old Kettle Falls Road (formerly the Cooke Mountain Road) route.

Alternative 4 - Alternate Sub-County Road Access for Backfill

Alternative 4 is the second alternative method for introducing backfill materials from the quarry located on the west side of the Wolfe Camp drainage to the underground mine workings on the east side of the valley. This alternative would allow trucks travelling between the Wolfe Camp quarry and the mine to pass under the Wolfe Camp road and enter the mine directly from an adit in the east valley wall.

Alternative 5 - Limited Mining Alternative - 2,750 Foot Level (Preferred Alternative)

In response to public comments, the BLM has developed a limited mining alternative for incorporation and analysis in the Final EISS. This alternative supplements the existing proposed mining alternative in the EISS, and is designed to prevent unnecessary or undue degradation to the water quality of the mining site. The limited mining alternative is intended to minimize potential water quality impacts by limiting mining to elevations above the post-closure water table predicted to be at 2,750 feet. Mining methods and reclamation would occur as described in the Proposed Action.

Alternative 6 - Limited Mining Alternative - 2,741 Foot Level

Alternative 6 is a mining alternative that is the same design as Alternative 5 except it incorporates the existing floor elevation of Zone 3 at the 2,741 foot level.

AFFECTED ENVIRONMENT

The proposed location of the Lamefoot project is in north central Ferry County, on the western slope of the Kettle River Mountain Range, seven miles northeast of the town of Republic, Washington. The surrounding area consists of gently rolling hills to steep mountainous uplands, with elevations ranging from 2,600 to 3,600 feet. The project area is mostly forested with a Douglas fir/ninebark community, with a few small wetlands supporting primarily a aspen/willow/dogwood community. A variety of wildlife, including mammals, birds, reptiles, and amphibians, occur in and around the project area. There are no records of rare, threatened, endangered, or otherwise special-status species in the Lamefoot area; however, there are several species of concern to the State of Washington in the vicinity.

The climate in the area of the Lamefoot Project is generally dry and cool, with an annual precipitation of 12 to 18 inches in the lower valleys to 30 inches or more at higher elevations, and an average annual temperature of 42.6°F. Air quality throughout the area is generally good.

ENVIRONMENTAL CONSEQUENCES

The alternatives described previously were evaluated for their potential impacts on various environmental, social, and cultural resources (See Section 4.0). A summary of the results of this evaluation follows.

Proposed Action

Development of the Lamefoot project, as proposed by Echo Bay and described in the Proposed Action, would require the disturbance of approximately 45-50 acres of land, including 7-12 acres of public land. Various impacts to groundwater; surface water; soil, water, and rock geochemistry; geology and subsidence, aesthetics and visual resources, transportation, noise, soils, and reclamation; air resources, recreation, socioeconomics, cultural resources, vegetation, and wildlife are detailed in Section 4.0.

Alternative 1 - No Action

The No Action Alternative implies that the existing condition of the environment will remain undisturbed by activities associated with the mine project. However, baseline environmental conditions do not reflect the current environmental conditions. Echo Bay currently has valid permits, issued by federal, state and local government agencies, for mining exploration activities in the project area. Some of the activities allowed under the exploration permit have modified existing environmental conditions. However, under this alternative, there would be no further environmental impacts, and areas disturbed during exploration would be reclaimed. In addition, the no action alternative would have negative socioeconomic impacts (see Table ES-1) resulting from the loss of jobs, earnings and tax revenue due to closure of the Lamefoot Exploration Program, Key Mill, and Echo Bay Kettle River operations office.

Alternative 2 - Alternate Drop Pass Backfill Access Method

This alternative would eliminate some of the traffic control and safety concerns associated with mine traffic crossing Wolfe Camp Road, and the road relocation program would be simplified to a single relocation at closure. However, this alternative would require the development of surface facilities such as collared openings for backfill drop passes (for both cemented and uncemented backfill material), an air vent, a drill hole opening for cement access, a cement silo with a baghouse, and possibly a crushing and screening plant, if backfill material is not sufficiently fragmented by blasting. The construction of these surface facilities would result in disturbance (within the 17 total acres of private land to be disturbed) as part of the Wolfe Camp quarry operations.

Alternative 3 - Alternate Ore Transportation Route

This alternative would require increasing the width and sight distance along parts of Fish Hatchery Road to accommodate increases in traffic. As a result, approximately three miles of the route would require upgrading. Increased noise, dust, and traffic on this route are also concerns to be considered.

Alternative 4 - Alternate Sub-County Road Access for Backfill

This alternative would eliminate traffic control and safety concerns associated with mine traffic crossing the Wolfe Camp Road, and would also eliminate concerns relating to poor rock quality and infiltration of groundwater associated with the subsurface, cross valley access ramp.

Alternative 5 - Limited Mining Alternative - 2750 Foot Level

This alternative would increase groundwater and geochemical impacts relative to the No Action Alternative; however, compared to the Proposed Action, these impacts would be reduced. Impacts to air quality, visual resources, transportation, recreation, wildlife and noise impacts would be the same as the Proposed Action during the life of the mine; however the reduced life of the mine would reduce the duration of the impacts. Beneficial impacts to socioeconomics are reduced due to the reduced life of the mine.

Alternative 6 - Limited Mining Alternative - 2741 Foot Level

This alternative would present the same impacts as Alternative 5.

Table ES-1 summarizes the environmental impacts from the proposed action and the alternatives considered in this EISS.

TABLE ES-1

SUMMARY OF LONG-TERM ENVIRONMENTAL CONSEQUENCES AND COMPARISON OF ALTERNATIVES

Resource	Unit of Measure	Proposed Action	No Action	Alternative Drop Pass Backfill Method	Alternative Ore Transportation Route	Alternative Sub-County Road Backfill Access	Limited Mine[2] Development 2750'	Limited Mine[2] Development 2741'
Groundwater								
Post Closure Mine Inflow	acre-feet/yr	18	6.25	>18	NC	NC	12.6	12.6
Private Wells Outside Permit Area	NA	NI	NC	NC	NC	NC	NC	NC
Quality	NA	-L	-L	NC	NC	NC	NC	NC
Quantity	NA	-L	NI	-M	NC	NC	NC	NC
Surface Water								
Quality	NA	-L	-L	NC	NC	NC	NC	NC
Quantity	NA	-L	-L	NC	NC	NC	NC	NC
Geochemistry								
Water Quality	NA	-L	-L	-M	NC	NC	NC	NC
Geology & Subsidence	NA	-L	NI	-L/M	NI	NC	NC	NC
Aesthetics/Quality of Life	NA	-L/M	-L	NC	NC	NC	NC	NC
Transportation	NA							
State Hwy. 21		-M/H	NI	NC	NC	NC	NC	NC
Wolfe Camp Rd.		-M/H	NI	-L/M	NC	-L/M	NC	NC
Other Roads		-L/M	NI	NC	NC	NC	NC	NC
Noise	-	-L	NI	NC	NC	NC	NC	NC
Soils	-	-L	-L	NC	NC	NC	NC	NC
Air Quality	-	-L	NI	NC	NC	NC	NC	NC

TABLE ES-1
(Continued)

Resource	Unit of Measure	Proposed Action	No Action	Alternative Drop Pass Backfill Method	Alternative Ore Transportation Route	Alternative Sub-County Road Backfill Access	Limited Mine[2] Development 2750'	Limited Mine[2] Development 2741'
Recreation								
Curlew Lake State Park	NA	-M/H	NI	NC	NC	NC	NC	NC
Other Recreation	NA	-L	NI	NC	NC	NC	NC	NC
Socioeconomics[1]								
Employment								
Direct	jobs	68	-141	NC	NC	NC	NC	NC
Indirect	jobs	102	-211	NC	NC	NC	NC	NC
Total	jobs	170	-352	NC	NC	NC	NC	NC
Earnings								
Direct	$M	17.4	-36.6	NC	NC	NC	5.8	5.8
Indirect	$M	7.2	-14.4	NC	NC	NC	2.4	2.4
Total	$M	24.6	-51.0	NC	NC	NC	8.2	8.2
Tax Revenue		10.8	-10.8	NC	NC	NC	3.6	3.6
Cultural Resources	-	NI	NI	NC	NC	NC	NC	NC
Vegetation*								
Forest (F)	acres	7	7	NC	NC	NC	NC	NC
Forest/Sagebrush (F/SG)	acres	7	7	NC	NC	NC	NC	NC
Sagebrush-Grass (SG)	acres	23	13	NC	NC	NC	NC	NC
Emergent Wetland (PEM)	acres	0	NI	NC	NC	NC	NC	NC
Forested/Shrub-Scrub Wetland (PFO/SS)	acres	0	NI	NC	NC	NC	NC	NC
Forested Wetland (PFO)	acres	0	NI	NC	NC	NC	NC	NC
Quarry	acres	8	8	NC	NC	NC	NC	NC

TABLE ES-1
(Concluded)

Resource	Unit of Measure	Proposed Action	No Action	Alternative Drop Pass Backfill Method	Alternative Ore Transportation Route	Alternative Sub-County Road Backfill Access	Limited Mine^2 Development 2750'	Limited Mine^2 Development 2741'
Total Acres	acres	45	35	NC	NC	NC	NC	NC
Special Status Species	--	+M	-L	NC	NC	NC	NC	NC
Wildlife								
Mule Deer Winter Range		+M	+H**	NC	NC	NC	NC	NC
Road Kill Hazard		-L	+L	NC	NC	NC	NC	NC
Timber Resources		-L	NI	NC	NC	NC	NC	NC

NI -	No Impact
NA -	Not Applicable
NC -	No Change from proposed action condition
*	Vegetation type acreages are approximate due to scale distortion of aerial photo.
**	Conditions expected to continue to improve as the plant communities reach climax conditions.
+	Beneficial Impact
-	Adverse Impact
L	Low
M	Moderate
H	High
[1]	Positive values represent an increase in the number of jobs or earnings due to proposed mining operations, while negative values represent a loss of jobs or earnings due to closure of the Lamefoot exploration program, Key Mill, and Echo Bay Kettle River operations office.
[2]	Levels of impact would not change relative to the Proposed Action, although their duration would be shortened to two years rather than six under the Proposed Action except as noted.

See introduction to Section 4.0 for explanation of impact criteria.

1.0
INTRODUCTION

1.0
INTRODUCTION

As part of the Kettle River Project, Echo Bay Minerals, Inc. (Echo Bay) is proposing to commercially produce from the Lamefoot Mine gold mining operation and expand the ancillary facilities (notably, the tailing facilities). This Environmental Impact Statement Supplement (EISS), prepared in compliance with the National Environmental Policy Act (NEPA), describes (1) the regulatory aspects of the proposed action and the alternatives, (2) the existing environment of the project area and the environmental consequences of the proposed action and the alternatives, (3) the cumulative impacts of expanding the Kettle River Project to include the Lamefoot site, and (4) measures proposed to mitigate those consequences. The proposed action includes a long hole, open stoping mining technique with backfilling, storage of waste rock, and transportation of the ore to an existing milling facility. Approximately 7 to 12 acres of land managed by the Bureau of Land Management (BLM) and 38 acres of private land will be disturbed as a result of previous and proposed actions at the Lamefoot operation. The Lamefoot Project would be located at a site in northern Ferry County, Washington shown on Figure 1-1.

1.1 GEOGRAPHIC SETTING

The Lamefoot Project Area is located along the western flank of the Kettle River mountain range of northeastern Washington State in north central Ferry County. The area is approximately 120 miles northwest of Spokane, seven miles northeast of Republic, and twenty miles south of Curlew, Washington. The project site is accessed from State Highway 21, which runs in a north/south orientation between Republic and Curlew. Access through the Lamefoot area from State Highway 21 is via Wolfe Camp Road (Echo Bay 1993a).

Figure 1-2 shows the general topography of the Lamefoot vicinity, and identifies site locations and access. The figure also shows the boundary of the study area considered in many of the baseline and impact studies. The Lamefoot Project Area includes portions of Sections 4 and 9, T37N, R33E and a small part of Section 33, T38N, R33E (Echo Bay 1993a).

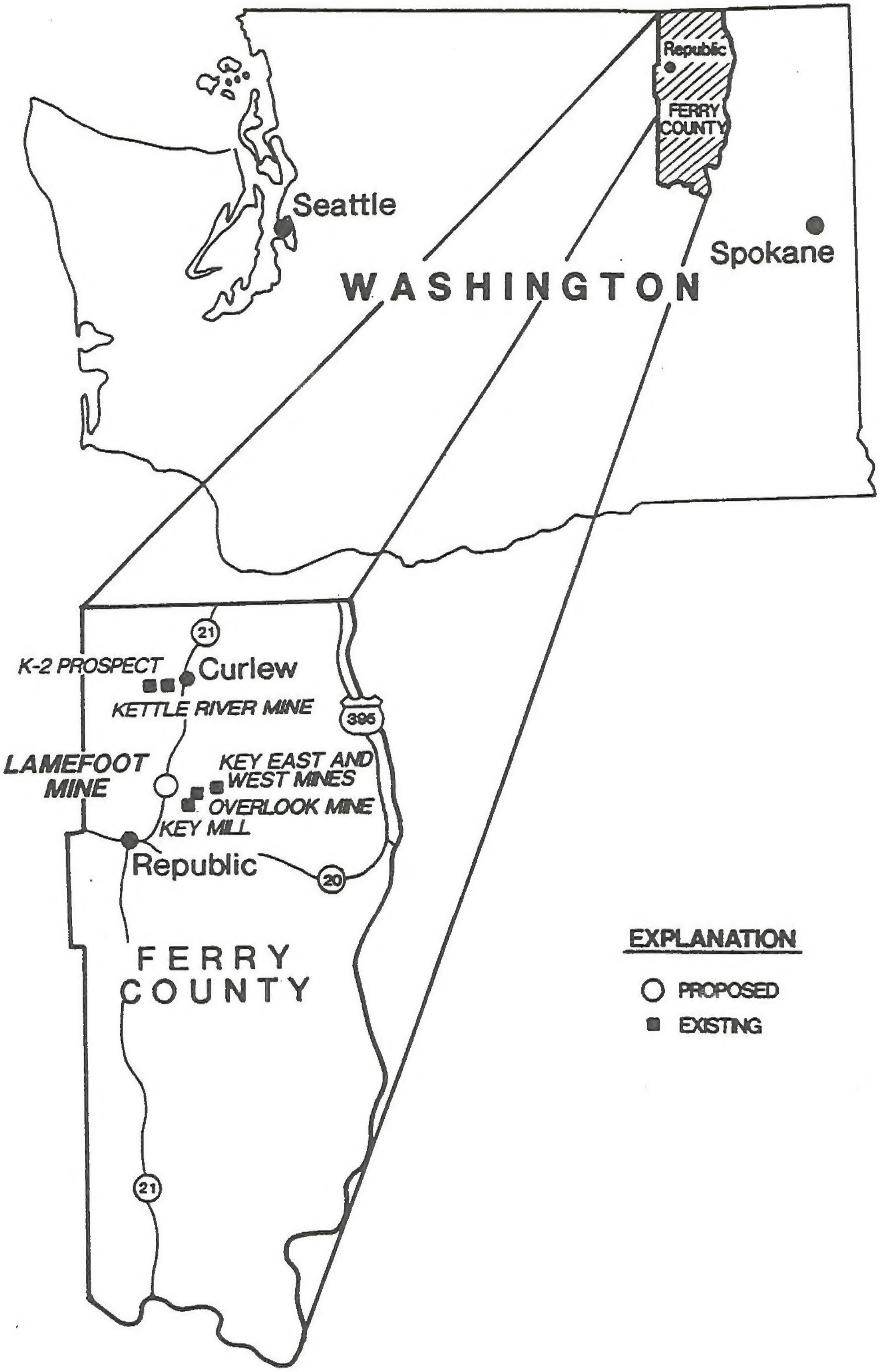
1.2 PROJECT AREA AND OWNERSHIP

Echo Bay controls minerals rights on more than 1,000 acres in the Lamefoot vicinity (Figure 1-3). Only a small fraction of this area is involved in the proposed commercial production phase. Ownership within the study area is a mosaic of public and private lands, and includes unpatented mining claims on BLM land, fee land owned by Echo Bay, and lands leased to Echo Bay by private entities and by the State of Washington (Echo Bay 1993a).

1.3 PURPOSE AND NEED

The proposed Lamefoot Mine will be an integral element in Echo Bay's Kettle River Operations, specifically upon depletion of reserves from two other mines (Key West and Key East) in the project vicinity; both of which are owned by Echo Bay (see Section 4.15, Cumulative Impacts, for details). The purpose of the Lamefoot Project is to extract gold ore from the underground mine, and to process the ore to produce an economically saleable resource. This ore is necessary for the continued operation of a regional mill facility. Specifically, the Lamefoot ore will be processed in the permitted Key Mill and stored in the Key tailing facility (Figure 1-2).

As described in the NEPA regulations (40 CFR 1502.1), the purpose of the EISS is to "provide full and fair discussion of significant environmental impacts and shall inform decision makers and the public of the



CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

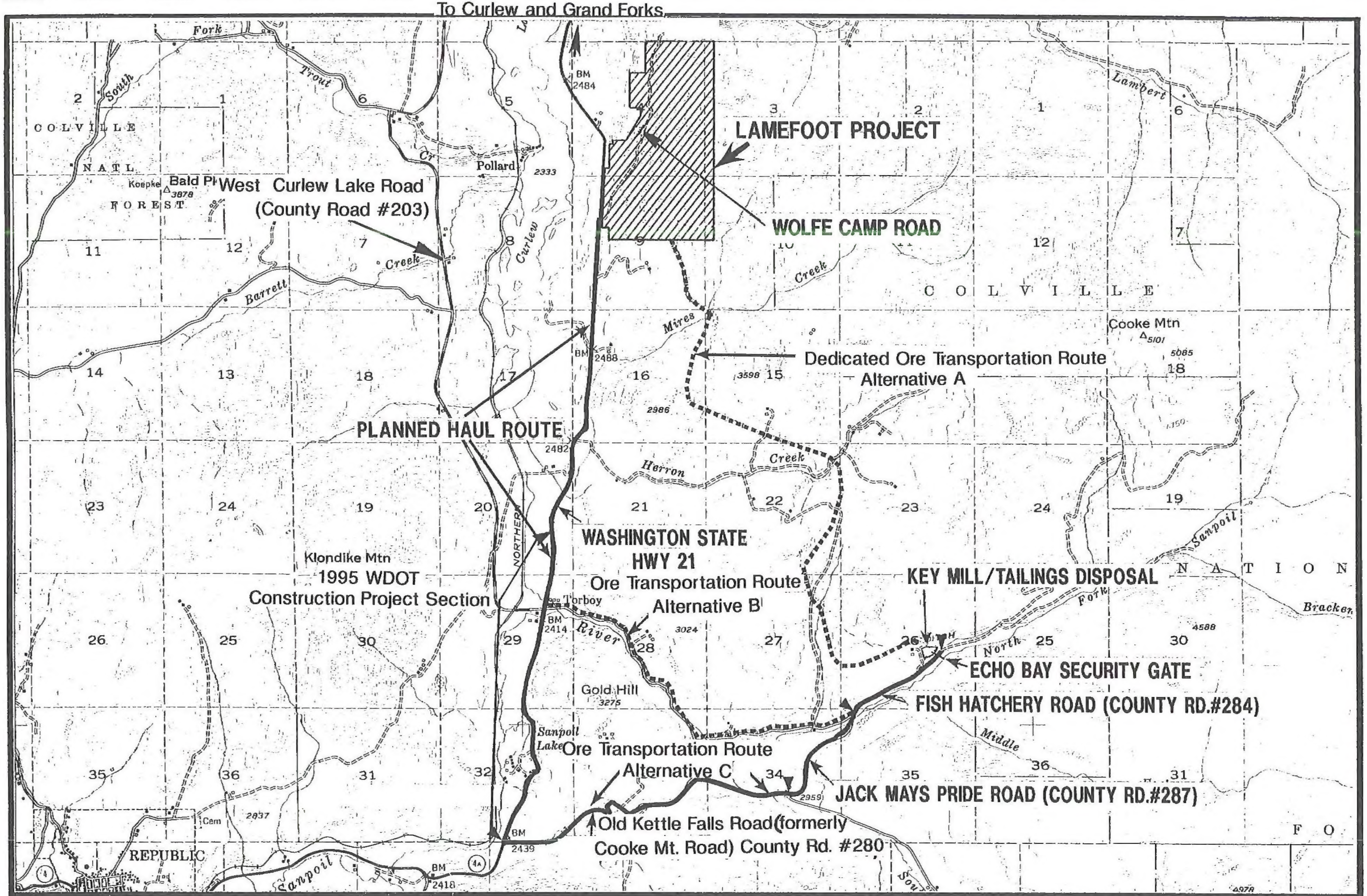
DRAWN	CHECKED J.C.	REVIEWED L.E.C.

TITLE

GENERAL LOCATION MAP

SOURCE: ECHO BAY, 1993a

DRAWN BDL	DATE APRIL 1993	JOB NO. 933-2614
CHECKED LEC	SCALE NA	DWG NO./REV. NO.
REVIEWED SHM	FILE NO.	FIGURE NO. 1-1

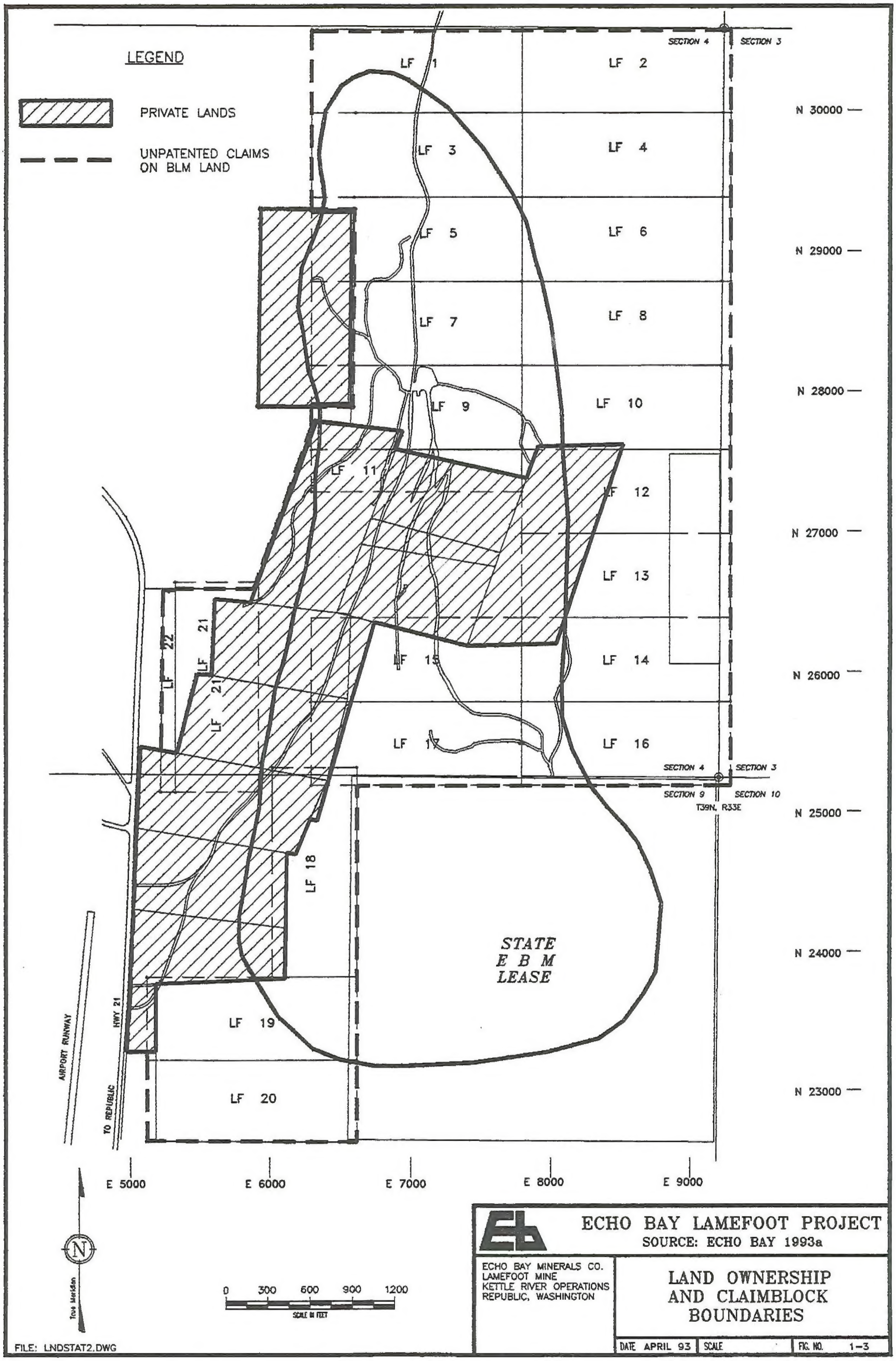


CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC,WASHINGTON

ECHO BAY MINERALS, INC.

TITLE
LAMEFOOT PROJECT
SITE ACCESS AND REGIONAL
TOPOGRAPHY
Source: Echo Bay 1993a

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE
BDL	LEC	SHM	APRIL 1993	1"= 1 MILE		933-2614		1-2



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAND OWNERSHIP AND CLAIMBLOCK BOUNDARIES

DATE APRIL 93	SCALE	FIG. NO. 1-3

FILE: LNDSTAT2.DWG

reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment."

An EISS is required to assess the impacts associated with further development of the Lamefoot site, including proposed mining and milling operations. The BLM will use this EISS to make a final decision concerning Echo Bay's Plan of Operations for the Lamefoot Project.

1.4 HISTORICAL BACKGROUND

In 1988, a Final Environmental Impact Statement (FEIS) (State of Washington DOE [Department of Ecology] 1988) was issued for the Kettle River Project, which at that time included two underground mines (Overlook and Kettle River), and a mill/tailing storage facility. Currently, both of these mines are idle, and ore is supplied to the mill by the two small open pit mines, Key East and Key West. A FEIS (USFS 1992) was completed in 1992 for the Key Project expansion. This EISS formally supplements that 1992 document.

Echo Bay began an exploration program at the Lamefoot site in 1989 on both private and federal land. The underground phase of the exploration program currently is in progress and is scheduled to continue through March, 1994. A Notice of Operations for exploration was initially submitted to the BLM in September of 1989 for surface drilling and road construction on 7 acres of federal land. Several modifications were made to that notice, and in November 1991, Echo Bay submitted a Plan of Operations to conduct surface and underground exploration that would exceed five acres of disturbance on land managed by the BLM. An environmental assessment for the exploration phase was completed in June, 1992, and the Plan of Operations for exploration activities was approved by the BLM on July 28, 1992. One condition of the approval was that Echo Bay submit a plan modification if exploration indicated that mining might be feasible. Echo Bay submitted the modified Plan of Operations for mining in April 1993, and supplemental information in July 1993.

In developing the proposed action, Echo Bay held informal meetings and independently consulted with local landowners and county officials during 1992 and 1993 to identify issues and concerns in the Republic and Curlew Lake vicinities.

1.5 EIS SUPPLEMENT PROCESS

As further described in the NEPA regulations (40 CFR 1502.14), an additional goal of the EISS process is to present the environmental impacts of the proposed action and alternatives in comparative form to sharply define the issues and provide a clear basis to assist the responsible officials in making decisions that are based on an understanding of the environmental consequences of the proposal.

The six basic development phases common to all EISS processes are summarized as follows:

1. Identification of issues and concerns from public and agency scoping meetings.

2. Summary of the proposed action and reasonable alternatives.

3. Description of environmental resources (the "affected environment") which may be impacted by the proposed action or alternatives.

4. Analysis of the impacts (the "environmental consequences") of the proposed action and alternatives, with presentation of results.

5. A public review and comment period, including a public meeting, occurring after publication of the Draft EISS. Substantive comments and responses are incorporated in the Final EISS.

6. A Final EISS and a Record of Decision are published on the proposed action or selected alternatives.

This EISS will therefore address potential impacts and mitigation associated with the expansion of the Lamefoot Mine, as well as the cumulative impacts regarding both mining and milling related to the addition of the Lamefoot Mine to overall Kettle River Operations.

1.6 SCOPING ISSUES

Comments, suggestions, and concerns about the proposed project were gathered during a public scoping period from May 7, 1993 through June 7, 1993, and are addressed in this EISS. A public scoping meeting was held in Republic, Washington on May 20, 1993. The primary issues of concern raised by the agencies and the public include effects of acid mine drainage, potential subsidence, visual and noise impacts, and transportation impacts. These issues will, therefore, receive particular attention in this EISS. A more detailed discussion of the issues raised to date is given in Section 6.4, Comment Analysis.

1.7 RELATIONSHIP TO BLM POLICIES, PLANS AND PROGRAMS

Approximately 24 percent of the total surface disturbance and 30 percent of the proposed underground mining may take place on public land managed by the BLM (Echo Bay 1993a). Under the United States mining laws, claimants and operators have the statutory right to locate mining claims on lands open to location. BLM has a duty under the Federal Land Policy Management Act of 1976 (FLPMA) to prevent unnecessary and undue degradation of the public lands.

Regulations promulgated under FLPMA require plans of operation be reviewed under the NEPA (43 CFR 3809.1-6). In addition to preparation of an environmental assessment for the exploration plan, the early phase of operations was reviewed as a cumulative impact under the EIS for the Key Project Expansion of the Kettle River Project. The decision for the Key Project Expansion required preparation of an EIS Supplement for the Lamefoot site because preliminary scoping suggested the possibility that the mining phase might result in additional significant cumulative impacts from interrelationships with the overall Kettle River Project.

Regulations under these various laws require the responsible federal agencies to review the applicant's Plan of Operations to ensure that:

- Adequate provisions are included to minimize, where feasible, adverse environmental impacts to resources on public lands and to prevent undue and unnecessary degradation (43 CFR 3809.0-6).
- Measures are included to provide for reclamation (43 CFR 3809.0-6).
- The proposed operations comply with other applicable federal, state, and local laws and regulations (43 CFR 3809.2-2, 43 CFR 3809.3-1).

1.8 OTHER PERMITS AND APPROVALS

In addition to BLM decisions on the Plan of Operations and NEPA compliance, other federal, state, and local regulatory agencies may require permits or other approval prior to Echo Bay being allowed to begin mining operations. Among the more important of these permits or decisions are those shown on Table 1-1. Some of these have already been obtained. Others are pending or not yet initiated. The agencies listed will use this EISS as a source document regarding baseline conditions and projected impacts.

TABLE 1-1

OTHER PERMITS AND APPROVALS*

	Agency	Type of Approval
State:	Department of Ecology	• Burning Permit - change of place or purpose of use approval • State Environmental Policy ACT (SEPA) compliance • Waste Discharge Permit #8033 • NPDES Permit No. 5 03-001184 • Public Groundwater Withdrawal Permit • Temporary Modification of Water Quality Criteria
	Department of Social Health Services	• New Source Construction Approval • Air Pollution Source Regulation • On-Site Sewage • Community Water System
	Department of Natural Resources	• Burning Permit
County:	Ferry County	• Building Permit • Road Relocation and/or Access • Ferry County Mining Ordinance • On-Site Sewage (Tri-County Health Department)
	Ferry County PUD	• Power Service Contract

*Adapted from Echo Bay 1993a.

2.0

PROPOSED ACTION AND ALTERNATIVES

2.0
PROPOSED ACTION AND ALTERNATIVES

2.1 OVERVIEW

This section describes the alternatives development process for the proposed Lamefoot project. As described in the NEPA regulations (40 CFR 1502.14), this process should include:

- Evaluation of all reasonable alternatives, including the no action alternative.
- Discussion of reasons for eliminating alternatives.
- Evaluation of appropriate mitigation measures not included in the proposed action or alternatives.

The process was initiated by Echo Bay's submittal of a Plan of Operations (POO) for exploration in 1992. Based upon the initial NEPA analysis, exploration proceeded until it was determined that mining was feasible. At that point in 1993, a modification to the POO was submitted to BLM to outline Echo Bay's proposed action. As noted in Section 1.0, the BLM subsequently completed a scoping process to solicit comments from the public and other concerned parties on the proposed action. Based on the information submitted by Echo Bay and the comments received during the scoping process, the BLM developed and refined a suite of alternatives for evaluation in the EISS. As a result of the public comments and new information three (3) additional alternatives were developed (e.g., Sub-County Road access for Backfill Alternative 4, Limited Mine Development - 2,750' Level Alternative 5, and Limited Mine Development - 2,741' Level Alternative 6).

2.2 ALTERNATIVES INCLUDED AND ELIMINATED

2.2.1 Alternatives Considered

Alternatives considered for the EISS for the Lamefoot project are summarized in Table 2-1. The alternatives were developed from documents on the proposed action, agency comments, public comments, experiences at other mining projects, and a review of the technical literature. The alternatives were evaluated based on engineering, environmental, and economic factors. Some alternatives were then eliminated. Technical implementability and technical effectiveness were included in the engineering evaluation. As a result of public comment on the draft EISS and additional analysis of the existing information by BLM, it was determined that additional data was needed. BLM believes this information would be needed to verify the conclusions identified in the impact analysis regarding full development of the mine as described in Echo Bay's Proposed Action. Therefore, as an alternative to full development, another alternative was included in the final EISS. This alternative involves limiting development of the mine as Echo Bay Co. has proposed by mining only that portion of the ore bodies located above the projected post closure water table of 2,750 feet mls. Subsequent to considering this alternative, Echo Bay requested that BLM consider permitting development of the ore body under Zone #3 down to the 2,741 foot msl elevation, since this is the level of the floor of an existing exploratory tunnel. These alternatives are described in detail in this chapter as Alternatives 5 & 6, respectively. The environmental evaluation considered potential impacts to air, water, and soil (land disturbance), with consideration of subsequent impacts to vegetation, wildlife, and the human environment. Relative cost and affordability were included in the economic evaluation.

Included alternatives are generally acceptable based on all three factors. Eliminated alternatives are generally unacceptable based on at least one of the factors. The following section provides more detail on why some alternatives were eliminated.

TABLE 2-1

ALTERNATIVES CONSIDERED FOR LAMEFOOT EISS

Category	Alternative	Included/Eliminated for Detailed Analysis	Reasons for Inclusion or Elimination
Mining Method	A) Open Pit	Eliminated	Extensive surface disturbance and potential noise, wetlands, and visual impacts. Also, some potential for impacts to air and water quality.
	B) Open Stope Mining without Backfilling	Eliminated	Extensive surface subsidence possible. Increased potential for water degradation through access to the underground workings. Also, a safety hazard to workers.
	C) Open Stope Mining with Pillars	Eliminated	Inefficient utilization of resources due to incomplete resource extraction. Surface subsidence possible. Water degradation in underground workings possible.
	D) Open Stope Mining with Backfill	Included	Viable and efficient means of resource extraction. Reduced potential for surface subsidence, water degradation, and visual impacts.
	E) Limited Mine Development - 2,750' Level	Included	Viable means of resource extraction. Reduced potential for water degradation.
	F) Limited Mine Development - 2,741' Level	Included	Viable means of resource extraction that incorporates the existing workings in Zone 3. Reduces potential for water degradation.
Backfill Access Method	A) Ramp access from Wolfe Camp Road Crossing	Included	Viable and effective means of backfill access.
	B) Drop Pass and Access Ramp without Wolfe Camp Road Crossing	Included	Viable and effective means of backfill access.
	C) Sub-County Road Access for Backfill	Included	Viable and effective means of backfill access.

TABLE 2-1
(Concluded)

Category	Alternative	Included/Eliminated for Detailed Analysis	Reasons for Inclusion or Elimination
Ore Transportation Routes	A) Newly-Constructed, Dedicated Haul Road	Eliminated	Extensive new surface disturbance. Likely unpaved, with potential for high particulate emissions and noise near residences. Route crosses both public and private lands.
	B) Existing Highway 21 and Fish Hatchery Road	Included	Short route along existing road alignment. Partially paved. Three miles would require upgrading.
	C) Highway 21 and Old Kettle Falls Road (formerly Cooke Mountain Road)	Included	Mostly paved route with least disturbance to local residents; requires no upgrading.
Waste Rock Disposal	A) Onsite Above Ground	Eliminated	Associated with open pit mining method; eliminated for same reasons.
	B) Onsite Below Ground	Included	Waste rock disposal with limited offsite impacts. Most appropriate for open stope with backfill, underground mining method. Involves temporary surface waste rock storage.
Milling and Tailings Disposal	A) Key Mill and Kettle River Tailings Facility	Included	Makes use of permitted facilities; existing, efficient means of milling and waste disposal; minimizes surface disturbance and impacts to other resources.
	B) Other Sites	Eliminated	Requires new construction, and involves unnecessary impacts to resources; additional surface disturbance.

2.2.2 Eliminated Alternatives

2.2.2.1 Open Pit Mining (Mining Method Alternative A)

An alternative mining method assessed for the Lamefoot Project was an open pit design. This alternative was initially evaluated by Echo Bay as the most cost-effective method for mining the Lamefoot ore deposit. This alternative would result in larger and more extensive disturbance of the surface on both private and BLM land than any underground alternative considered. Total area of an open pit mine at Lamefoot for the entire possible orebody would be at least 40 acres, about 10 of which would be on public land.

The estimated 40 or more acres of surface disturbance associated with open pit mining would not include acreage for access roads or waste rock disposal areas. Disposal and storage of approximately 22 million tons of waste rock would require substantial additional surface disturbances, including probable environmental impacts associated with disturbances to springs and wetlands. Potential minimum disturbance areas for an open pit alternative, including waste rock disposal areas, are shown on Figure 2-1.

This alternative has been eliminated based on the more extensive surface disturbance and hydrologic impacts associated with the open pit mining and waste rock disposal plan (compared to the proposed action); and also due to likely high adverse impacts regarding noise, visual resources, and wetlands in this location.

2.2.2.2 Open Stope Mining Without Backfilling (Mining Method Alternative B)

Initially, Echo Bay presumed that the best underground method of mining would be long hole sublevel open stoping. (This is the proposed action method, with backfill added.) However, geotechnical evaluation of this method, without backfilling, led to the conclusion that potential ground instability of certain areas overlying stopes might compromise worker safety. Therefore, this alternative has been eliminated.

2.2.2.3 Open Stope Mining Leaving Pillars (Mining Method Alternative C)

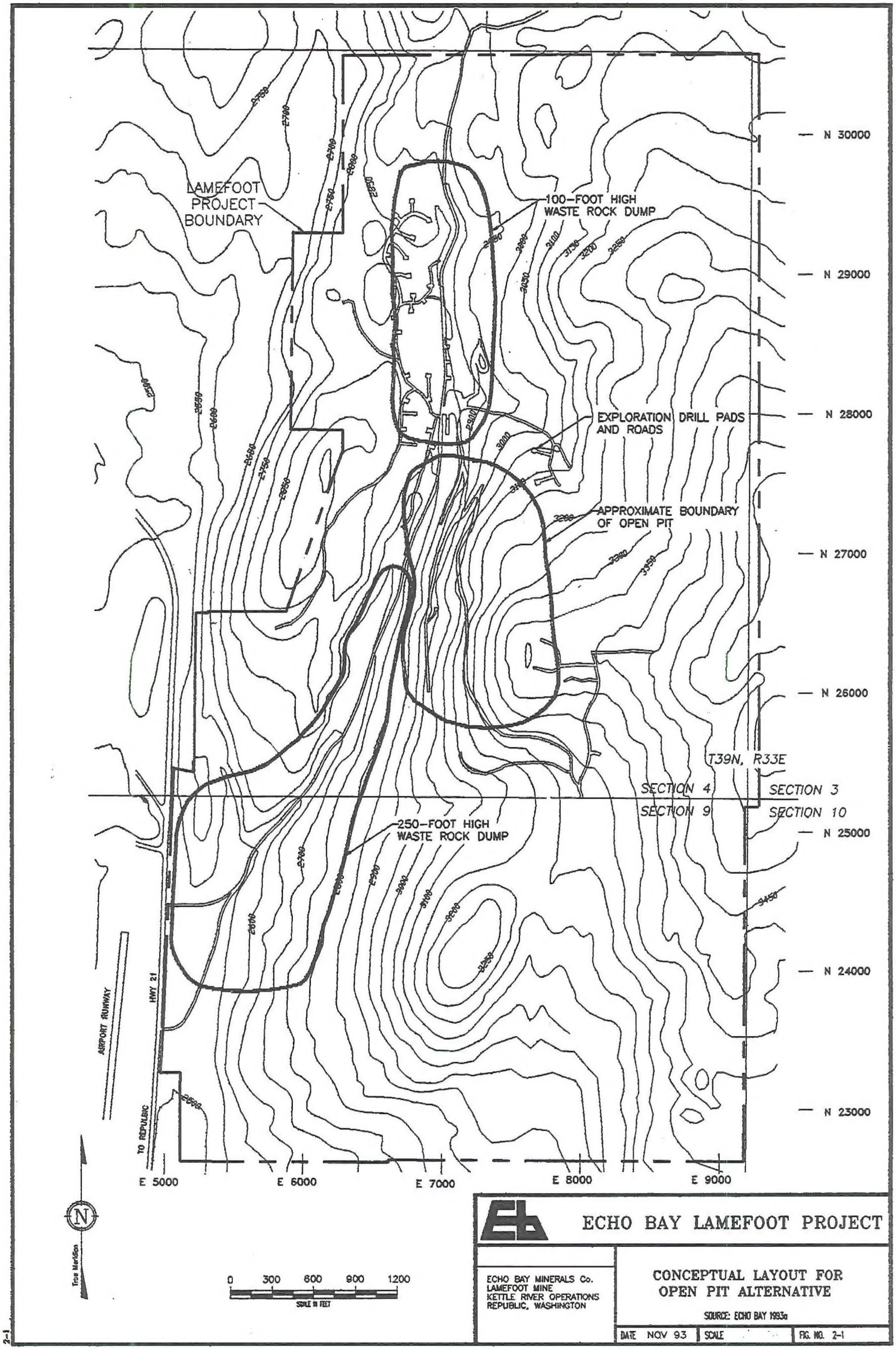
Another alternative mining method previously assessed was an underground mine design, which incorporated the use of pillars to prevent subsidence. (Pillars are unmined blocks of ore left after mining, to provide structural integrity to the mined area.) It was found that the large amount of ore required for adequate pillar support would result in inefficient utilization of resources due to incomplete extraction . In addition to being an inefficient use of resources, mining of the Lamefoot deposit would not be economical. Therefore, this alternative has been eliminated.

2.2.2.4 Dedicated Ore Transportation Route (Transport Route Alternative A)

A dedicated haul road (shown as Transport Route Alternative A, Figure 1-2) would be the shortest route between the mine and the mill, but would require construction of a new road along the most direct feasible road alignment. The dedicated road would be designed and constructed by Echo Bay to accommodate large off-highway haul trucks, and would be unpaved. This alternative would result in the largest amount of surface disturbance (123 acres) of the ore transport alternatives considered, and particulate emissions from this road would be the highest (Echo Bay 1993a). Land would necessarily be purchased from private individuals, and federal land would also be disturbed. Therefore, this alternative has been eliminated.

2.2.2.5 Other Sites For Milling and Tailings Disposal (Milling and Tailings Disposal Alternative B)

This alternative was eliminated primarily due to the desirability of limiting disturbance to one area by making use of existing, permitted facilities. Construction of an unneeded, second mill would involve additional environmental impacts that would be contradictory to BLM's policy of preventing "undue and unnecessary degradation." In addition, Echo Bay has indicated that the construction of an additional $40



ECHO BAY LAMEFOOT PROJECT

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

CONCEPTUAL LAYOUT FOR OPEN PIT ALTERNATIVE

SOURCE: ECHO BAY 1993a

DATE NOV 93 | SCALE | FIG. NO. 2-1

million mill and tailings facility would cause mining the Lamefoot ore deposit to be uneconomical (Echo Bay 1993c).

2.2.3 Alternatives Included in the EISS

The alternatives remaining, which were selected for inclusion in the EISS analysis, are listed below and summarized in Table 2-2.

- Proposed Action
  - Underground Open Stope Mining with Backfill (Mining Method Alternative D)
  - Ore Transport via Highway 21 and Old Kettle Falls Road (Ore Transport Route Alternative C)
  - Backfill access from Wolfe Camp Road crossing (Backfill Access Alternative A)
  - Waste Rock Disposal On Site Below Ground (Waste Rock Disposal Alternative B)
  - Milling and Tailings Disposal at Key Mill and Kettle River Tailings Facility (Milling and Tailings Disposal Alternative A)
  - Reclamation
- Alternative 1 - No Action
  - Operating Permit Denied
  - Exploration and Development Ceases
  - Reclamation
- Alternative 2 - Alternative Drop Pass Backfill Access Method
  - Backfill Drop Pass and Access Ramp without Wolfe Camp Road crossing (Backfill Access Alternative B)
- Alternative 3 - Alternative Ore Transport
  - Ore transport via Highway 21 and Fish Hatchery Road (Ore Transport Route Alternative B)
- Alternative 4 - Alternative Sub-County Road Access for Backfill.
  - Backfill access under Wolfe Camp Road (Backfill Access Alternative C)
- Alternative 5 - Limited Mine Development - 2750' Level
  - Mine development above the water table at 2750 feet.
- Alternative 6 - Limited Mine Development - 2741' Level
  - Incorporates existing workings in Zone 3.

TABLE 2-2

LAMEFOOT EISS - ALTERNATIVES SUMMARY

Project Components	Proposed Action (PA)	Alternative 1 No Action	Alternative 2 Alternate Drop Pass Backfill Access Method	Alternative 3 Alternate Ore Transportation Route	Alternative 4 Sub-County Road Access For Backfill	Alternative 5 Limited Mine Development - 2,750' Level	Alternative 6 Limited Mine Development - 2,741' Level
Mine							
Location	Underground expansion	Existing underground workings (exploration decline and adits)	Proposed Action (PA)	PA	PA	Underground expansion to the 2,750 foot level	Underground expansion to the 2,741 foot level
Extraction	Open stope with backfill - 1,640,300 tons proven and probable ore - 1,327,600 tons possible ore - 350,000 tons waste		PA	PA	PA	Open stope with backfill - 1,020,000 tons proven and probable ore - 630,000 tons possible ore - 173,000 tons waste	Open stope with backfill - 1,020,000 tons proven and probable - 630,000 tons possible ore - 173,000 tons waste
Waste Rock Disposal	Underground		PA	PA	PA	PA	PA
Rock Borrow for Backfill - Location Along Wolfe Camp Road - 1,000,000 cubic yards		None	Along Wolfe Camp Road - 1,000,000 cubic yards		Under Wolfe Camp Road	PA	PA
- Access to Workings	Cross Wolfe Camp Road to Access Tunnel/Ramp	None	Drop Passes from Borrow Pit Floor		Cross under Wolfe Camp Road to Drop Passes from Adit in East Valley Wall of Wolfe Camp Drainage Workings	PA	PA
Ore Transport							
Loading	Front End Loader		PA	PA	PA	PA	PA
Route	Highway 21 and Old Kettle Falls Road		PA	Highway 21 and Fish Hatchery Road	PA	PA	PA

TABLE 2-2
(Concluded)

Project Components	Proposed Action (PA)	Alternative 1 No Action	Alternative 2 Alternate Drop Pass Backfill Access Method	Alternative 3 Alternate Ore Transportation Route	Alternative 4 Sub-County Road Access For Backfill	Alternative 5 Limited Mine Development - 2,750' Level	Alternative 6 Limited Mine Development - 2,741' Level
Method	Truck haul		PA	PA	PA	PA	PA
Milling and Processing	Key Mill		PA	PA	PA	PA	PA
Tailings Disposal	Kettle River Tailings Facility		PA	PA	PA	PA	PA
Reclamation	Backfill underground workings, remove structures, regrade, topsoil and revegetate surface disturbance.	Remove structures, regrade, topsoil and revegetate waste rock stockpiles and other surface disturbance.	PA	PA	PA	PA	PA

Each of the alternatives listed above is introduced briefly below, and described in detail in the text, maps, and diagrams which follow.

2.3 PROPOSED ACTION

2.3.1 General

The Proposed Action for the proposed Lamefoot Project is largely based on Sections 1, 2 and 3 of Echo Bay's Lamefoot Plan of Operations (Echo Bay 1993a), supplemented with information on the Key Mill and tailings impoundment from the Final EIS, Kettle River Project (State of Washington DOE 1988) and the Phase II Tailings Pond Expansion Summary Report (Golder 1992a). Additional information has been added where clarification is needed; however, the summary below is concise compared to the level of detail in these documents.

The Proposed Action also includes the exploration drilling activities for Phases I and II of Echo Bay's Lamefoot Exploration Program. These activities are described in the July 1993 Plan of Operations (Echo Bay 1993a) and are summarized in Section 2.3.11 of this EISS.

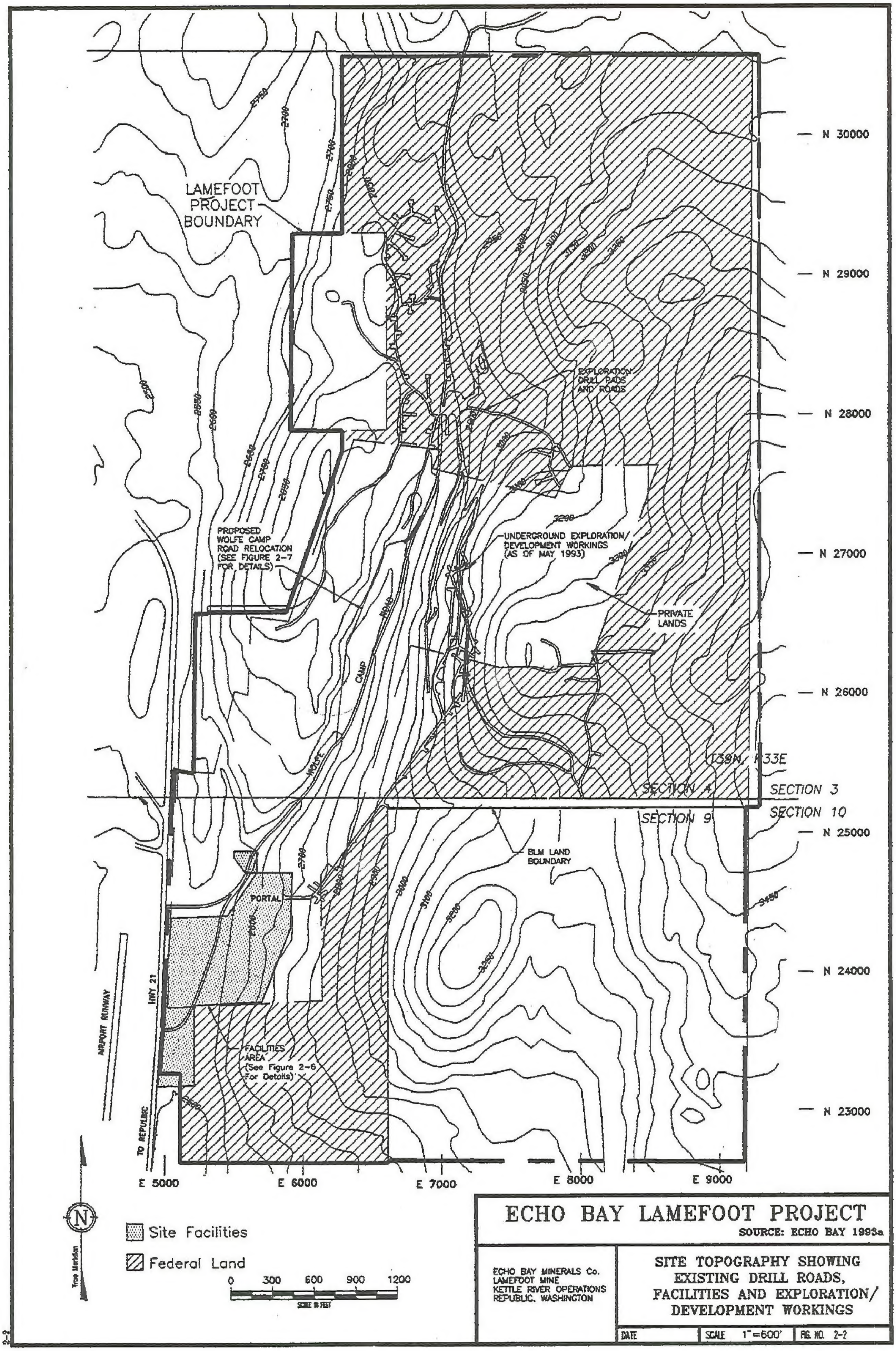
The Lamefoot Project is one component of the Kettle River Operations, a gold mining and processing complex located in Ferry County, Washington. Figures 1-1 and 1-2 show locations of the various elements of the Kettle River Operation. The Lamefoot Project has been an ongoing exploration program since 1989, involving the evaluation of a mineralized gold deposit for commercial production. The first phase of exploration utilized surface drilling to discover and delineate this deposit. The second phase, currently in progress, employs underground exploration mining and drilling techniques. This EISS addresses the development and commercial mining phases. However, special emphasis is placed on the commercial mining proposed to begin in 1994 and on potential additional surface exploration to explore for the continuation of gold mineralization.

The commercial mining phase of the Lamefoot Project would involve the extraction of ore from the mineralized body, and transportation of the ore via state and county roads to the existing, previously permitted milling facility and tailings impoundment (Figure 1-2). Approximately 85 percent (38 acres) of the underground mining would occur underlying private land, with 15 percent (7 acres) underlying BLM land. As of March 1993, the areal extent of the underground workings, including the access tunnel, totaled 7.3 acres (Figure 2-2). An oblique view of the proposed underground workings, including commercial development, is shown on Figure 2-3.

The proposed mining would be accomplished by a long hole open stoping mining technique. This method entails drilling blast holes between existing mining levels within the ore body, and blasting the rock so that it may be accessed from lower levels. The ore would then be loaded into underground trucks for transport to the surface. Highway trucks would haul the ore by state and county roads to the processing facility.

The ore would be processed by the conventional carbon-in-leach method at the existing Key Mill. Process tailings (after extraction of gold) would be permanently stored in a zero-discharge, lined tailings facility. (The current tailings impoundment is located on private land, and is scheduled and permitted for enlargement in 1993 through 1995.) Process waters are treated in a cyanide destruction circuit before discharge to the tailings pond and subsequent recycling for use in the milling circuit. The mill and fully expanded tailings disposal facility are shown in plan and section on Figures 2-4 and 2-5.

Waste rock from underground development would be deposited by underground trucks in temporary waste storage stockpiles at the Lamefoot site (Figure 2-6). Waste rock would be placed on limestone pads to prevent acid rock drainage. Most of the waste rock generated during both the commercial mining phase and the current exploration phase would be hauled underground before or upon completion of mining in



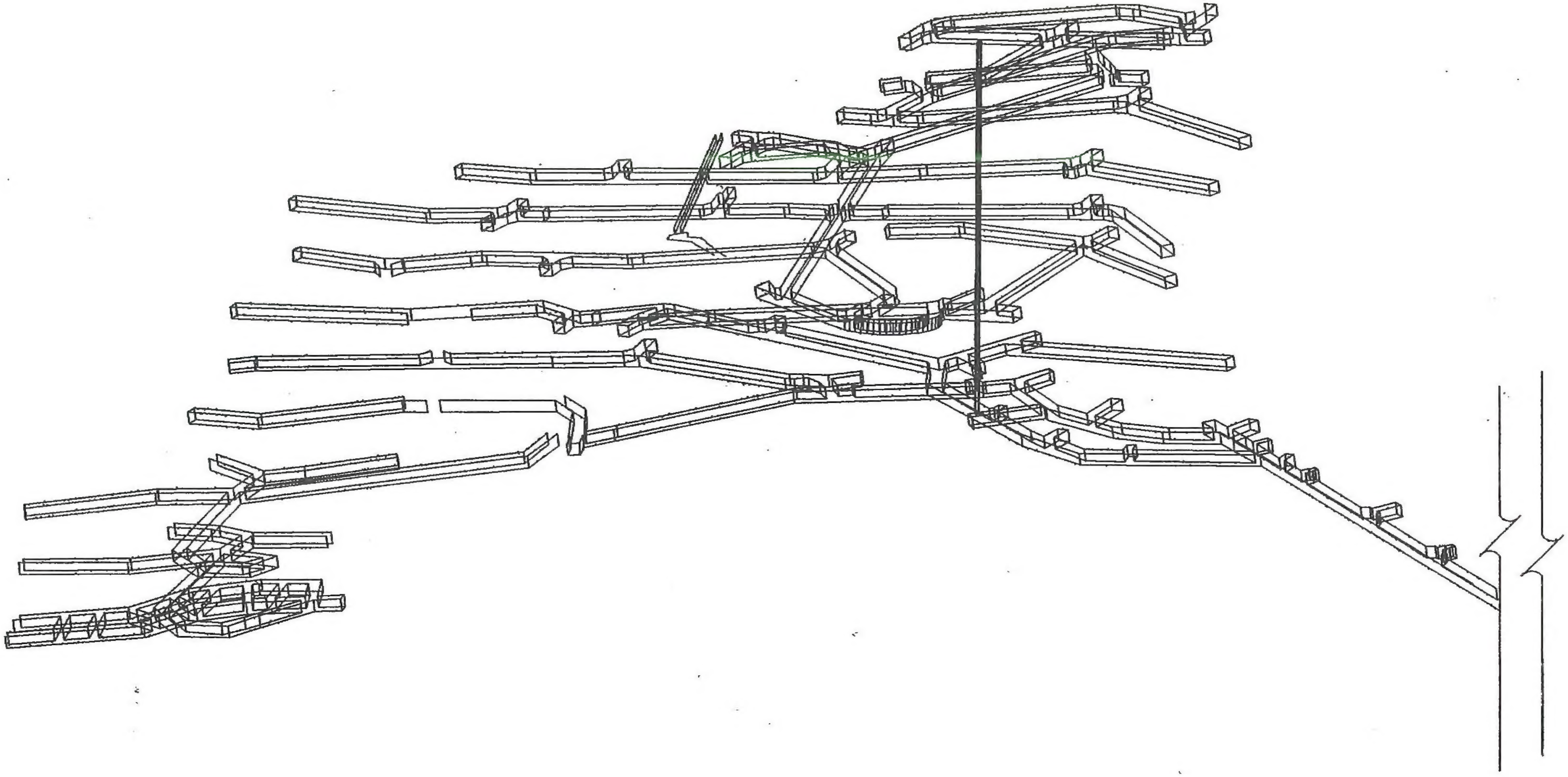
ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

SITE TOPOGRAPHY SHOWING
EXISTING DRILL ROADS,
FACILITIES AND EXPLORATION/
DEVELOPMENT WORKINGS

DATE	SCALE 1"=600'	FIG. NO. 2-2



FILE: 2-3

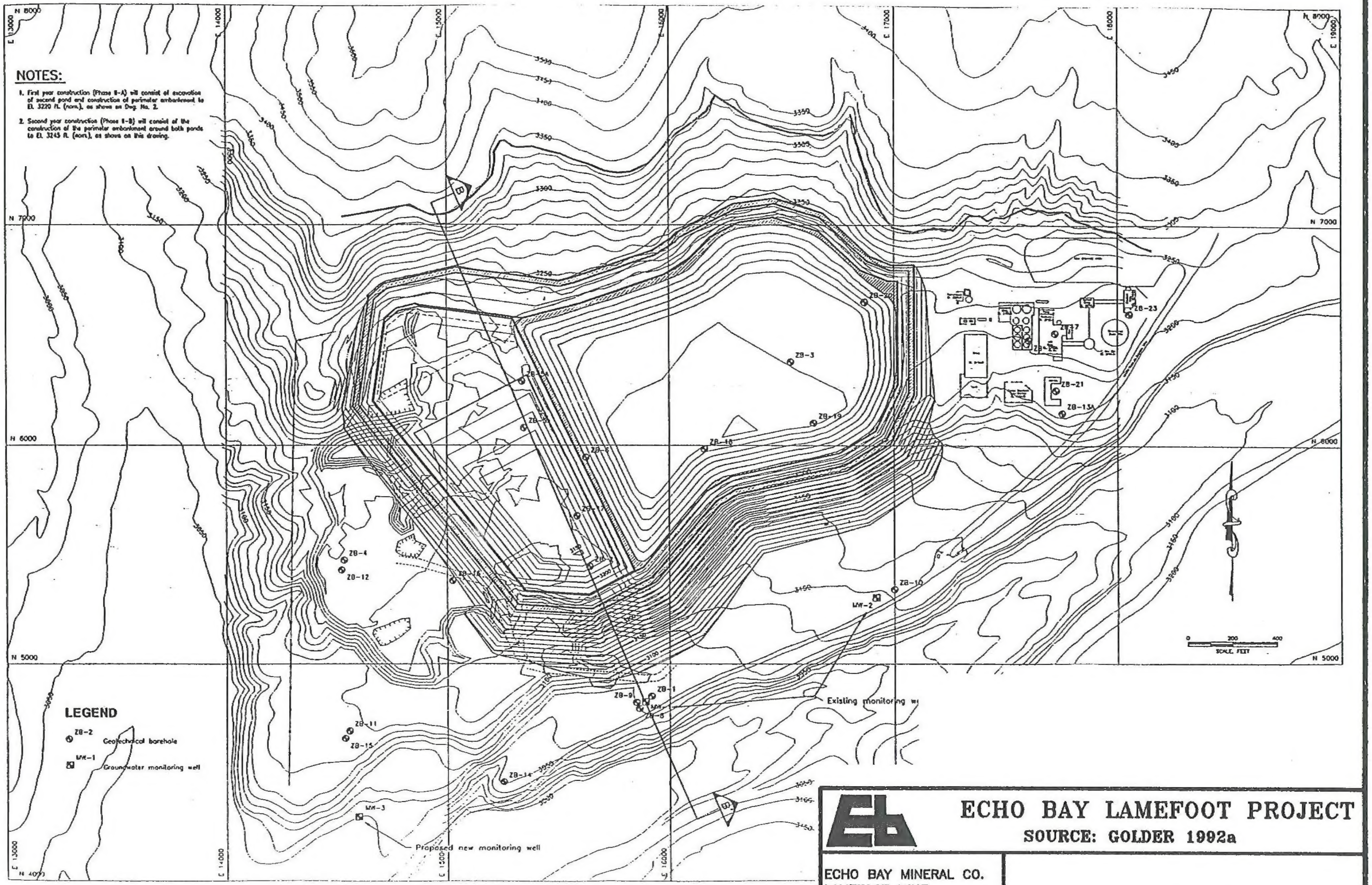
ECHO BAY LAMEFOOT PROJECT

Source: Adopted from Echo Bay 1993a

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

OBLIQUE VIEW OF UNDERGROUND EXPLORATION AND COMMERCIAL DEVELOPMENT PROGRAM

NOV 93	SCALE 1"=100'	FIG. NO. 2-3



NOTES:

1. First year construction (Phase II-A) will consist of excavation of second pond and construction of perimeter embankment to El. 3220 ft. (nom.), as shown on Dwg. No. 2.
2. Second year construction (Phase II-B) will consist of the construction of the perimeter embankment around both ponds to El. 3245 ft. (nom.), as shown on this drawing.

LEGEND

ZB-2 Geotechnical borehole

MW-1 Groundwater monitoring well

ECHO BAY LAMEFOOT PROJECT

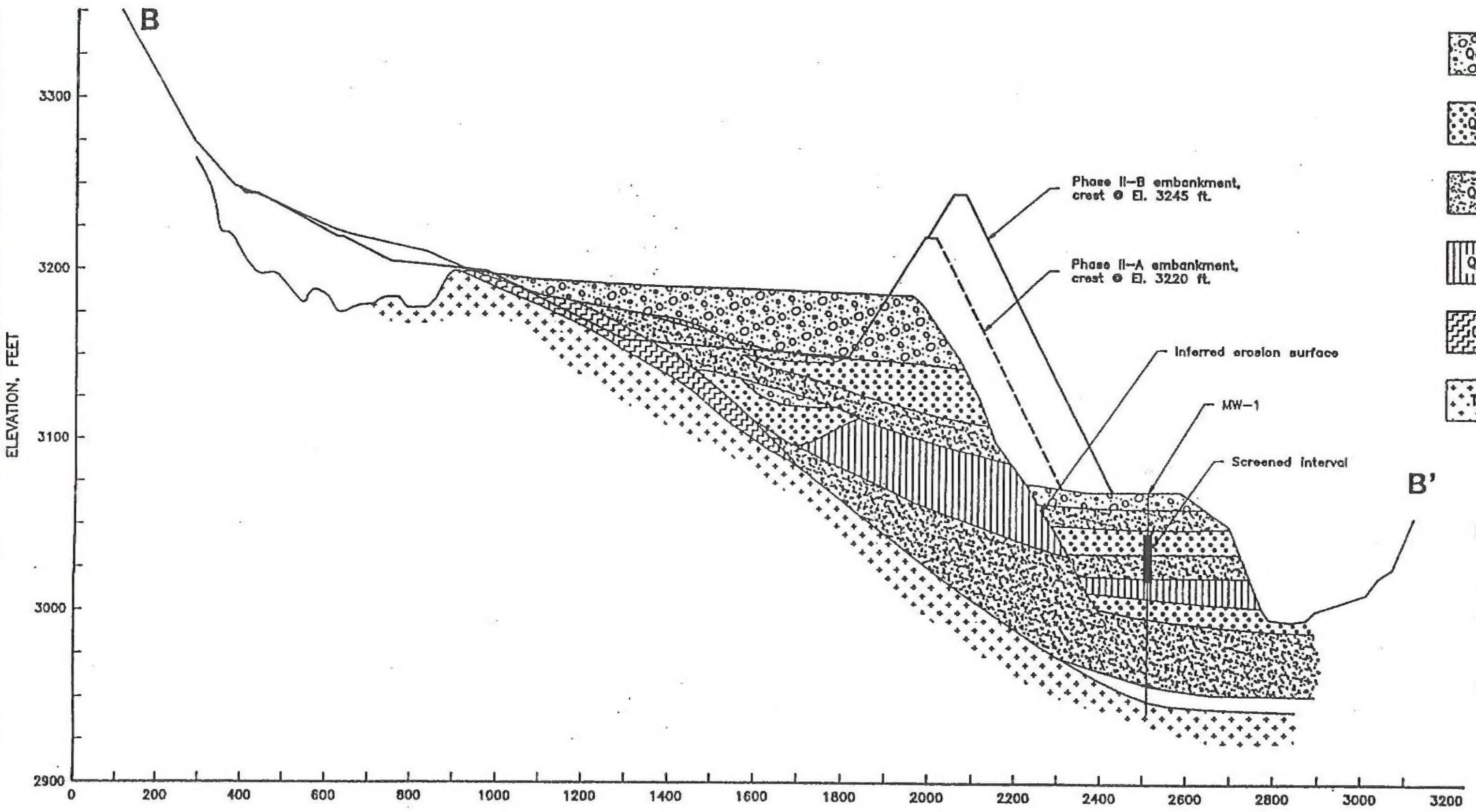
SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

FACILITY LAYOUT

DATE: JUNE 1994	SCALE:	FIG. NO. 2-4

EB1



LEGEND

MW-1 Monitoring well

Qa_vc	Engineering Unit 1 – Quaternary Alluvium (Very Coarse): Fine to coarse sand and fine to coarse gravel; some cobbles and boulders.
Qa_c	Engineering Unit 2 – Quaternary Alluvium (Coarse): Fine to coarse sand and fine to coarse gravel; occasional trace silt.
Qa_f	Engineering Unit 3 – Quaternary Alluvium (Fine): Fine to coarse sand, little silt, to fine to coarse sand and silt; occasionally little fine to coarse gravel.
Qgl	Engineering Unit 4 – Quaternary Glacio-Lacustrine: Silt, interbedded with fine sand and clay; occasionally little medium to coarse sand and trace fine to coarse gravel.
Qt	Quaternary Till: Fine to coarse sand; some fine to coarse gravel; some silt and clay; some cobbles. Non-stratified.
Tv	Tertiary Volcanics: Massive, brown to pale gray, composed of <1 to 3 mm phenocrysts of feldspar and mafics in aphanitic ground mass.

NOTES:

1. Cross section is drawn with 4x vertical exaggeration.
2. See Figure 1 for location of cross section.
3. Data concerning the various strata have been obtained at the boring locations only. The soil stratigraphy between these locations has been inferred from geologic evidence and will likely vary from that shown.
4. Bedrock surface developed from seismic (Schwarz, 1988) and borehole data.

MW-1 Monitor Well

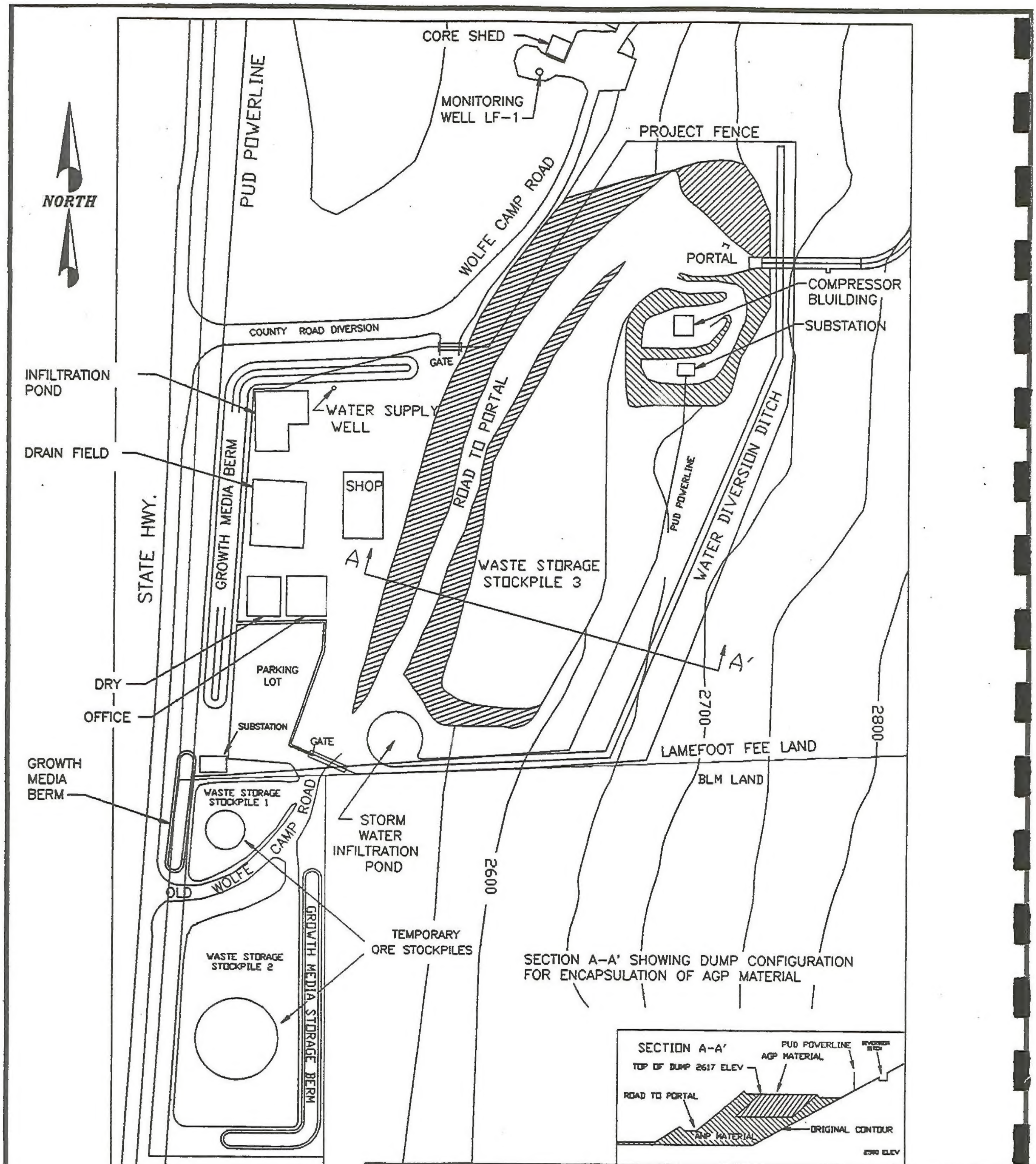
ECHO BAY LAMEFOOT PROJECT
SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

KEY MILL TAILING POND
GEOLOGIC CROSS-SECTION
B-B'

DATE: JUNE 1994 | SCALE: | FIG. NO. 2-5

EB1



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

FACILITY LAYOUT

DATE: APRIL 1993 | SCALE: 1" = 200' | FIG. NO. 2-6

LFDUMP1

individual areas, and used as backfill, to provide ground support (Echo Bay 1993c). Approximately 100,000 tons of limestone will remain on the surface for use in recontouring the portal area. The existing buildings would be dismantled and the office/shop site and other surface disturbance would be revegetated. Drill roads and pads from previous and future surface exploration programs would be reclaimed.

Mined-out areas within the Lamefoot underground workings would be backfilled with rock as required to prevent subsidence. Rock would be obtained from the temporary waste rock stockpiles and from the borrow area west of the proposed backfill portal and north of the main portal. Wolfe Camp Road would be relocated to an alignment through this excavation at the end of mine life (Figures 2-7 and 2-8).

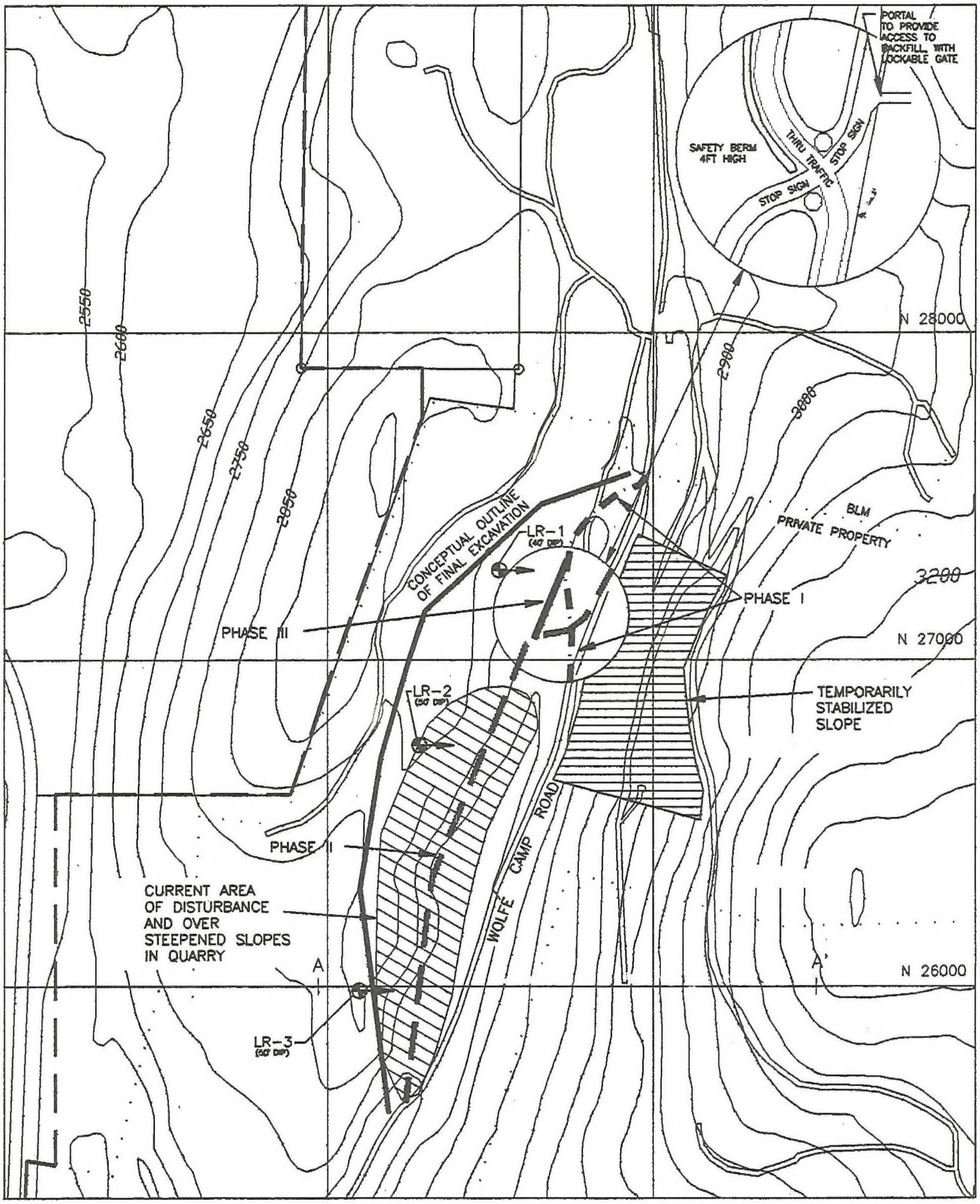
No additional surface disturbance from mining on public land is anticipated after completion of the on-going and permitted exploration phase. However, additional surface exploration will occur, and there will be additional surface disturbance associated with drilling activities. The surface disturbance associated with that activity would probably be less than five acres and would be conducted in the same fashion as the original exploration on public lands.

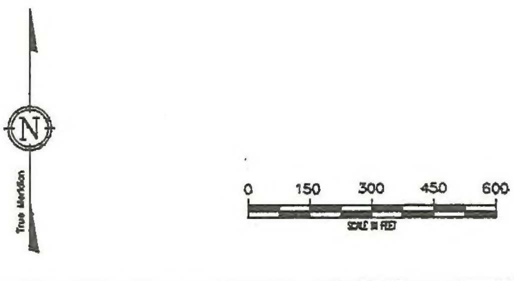
2.3.2 Project Schedule

Commercial production is proposed to commence at the Lamefoot Project upon completion of the Exploration/Development Phase II program. Initially, one mining area will be chosen for stoping (commercial production). Others will follow as feasibility allows. It may take several weeks following startup of commercial mining for full production capacity to be realized. Six ore zones have been delineated within the Lamefoot orebody. The locations of Zones 1 through 4 are shown on Figure 2-9. Zones 5 and 6 are not yet as well defined as Zones 1 through 4. However, available information on Zone 5 indicates that this portion of the orebody is located adjacent and parallel to Zone 4, approximately 100 feet west in the Zone 4 hanging wall. Current estimates indicate that Zone 5 may extend from 27,000 north to 27,400 north between elevations 2400 and 2680 feet. Zone 6 is located beneath Zone 4. Current estimates indicate that Zone 6 may extend from 27,000 north to 27,400 north with a central elevation of approximately 2200 feet. The mining schedule for all six zones is shown on Figure 2-10.

The duration of mining at the Lamefoot deposit will depend upon the results of the exploration/development project currently in progress and the ultimate feasible production rate sustainable by the resource. Mining rate may also be impacted by other factors such as gold price and alternate ore sources. Current reserves are calculated based on a gold price of $350 per ounce (Echo Bay 1993c).

Year-end 1992 reserves in the "proven and probable" category total 1,640,300 tons, and "possible" reserves are about 1,327,600 tons (including 100,000 tons of anticipated production during the exploration phase). If all of the probable and possible reserves were to be deemed minable based on the results of the exploration/development programs and a tonnage rate of 1500 tons per day were assumed, the duration of the uninterrupted commercial mining phase would be about six years. The actual mining rate will be determined by the size and geometry of the resource as determined by the exploration program. This rate is expected to be between 1,200 and 2,000 tons per day. The total waste expected to be produced over the life of the mine (including probable and possible reserves) is 260,000 tons during exploration and 90,000 tons during production, for a total of about 350,000 tons. If additional ore is found, more waste will be produced. The exact geometry of the underground workings may change, as constructed, therefore, waste volumes will vary based on engineering design.





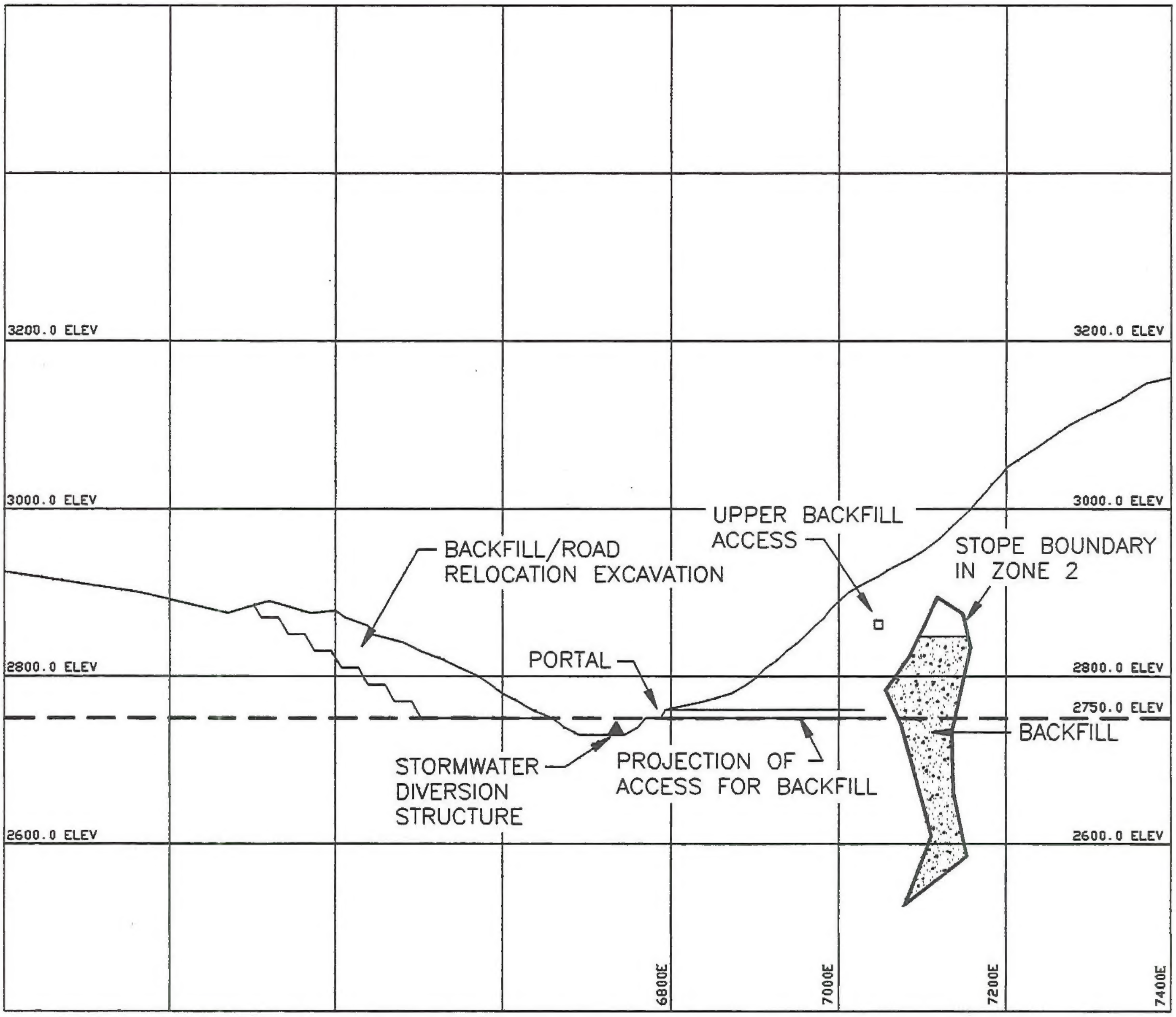
ECHO BAY LAMEFOOT PROJECT

Source: Echo Bay 1993a

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

CONCEPTUAL PROPOSED DIVERSION OF WOLFE CAMP ROAD

DATE: APRIL 1993
SCALE:
FIGURE NO. 2-7



ECHO BAY LAMEFOOT PROJECT

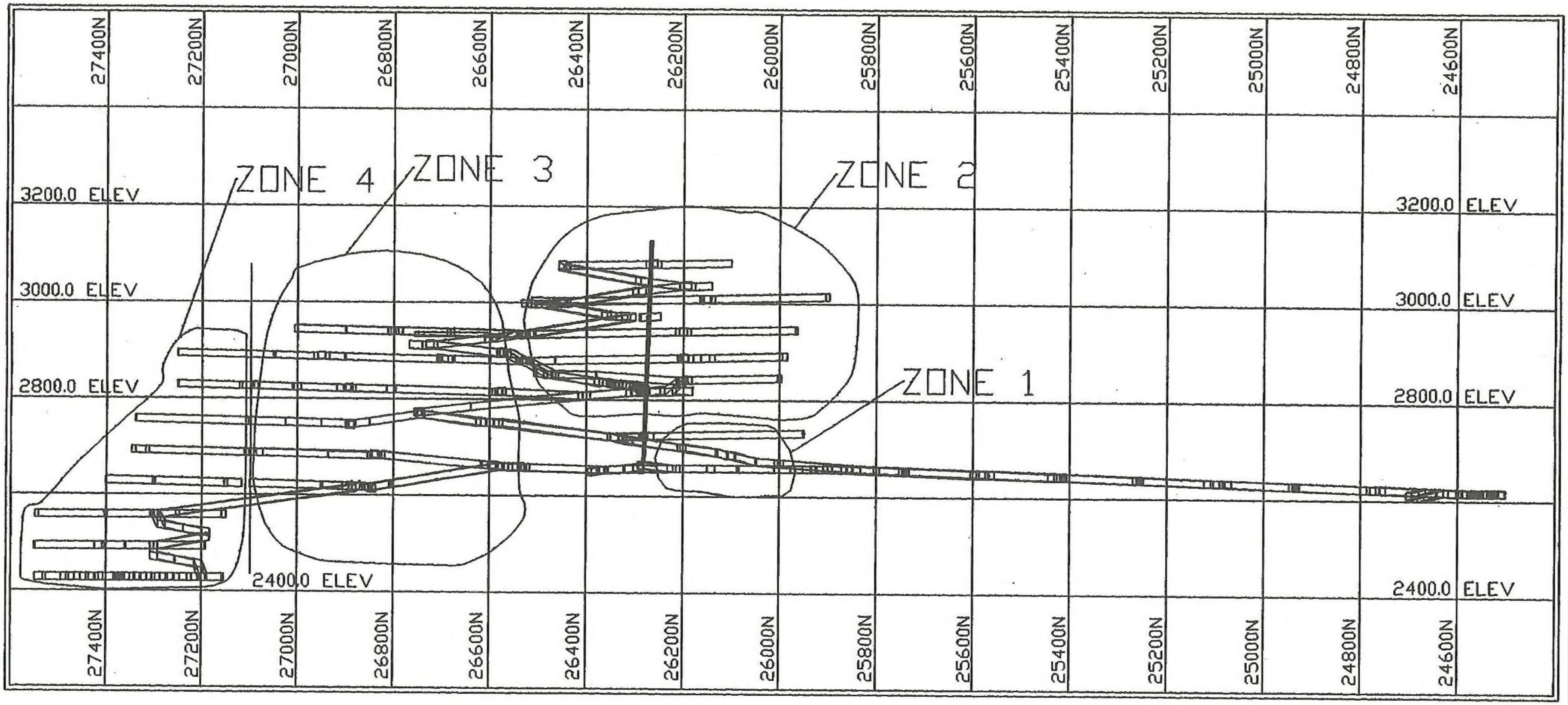
SOURCE: ECHO BAY 1993a

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

GENERALIZED CROSS SECTION OF LAMEFOOT AREA SHOWING BACKFILLED STOPE AND ROAD RELOCATION EXCAVATION

DATE APRIL 93 | SCALE 1"=200' | FIG. NO. 2-8

SECTION2



ECHO BAY LAMEFOOT PROJECT

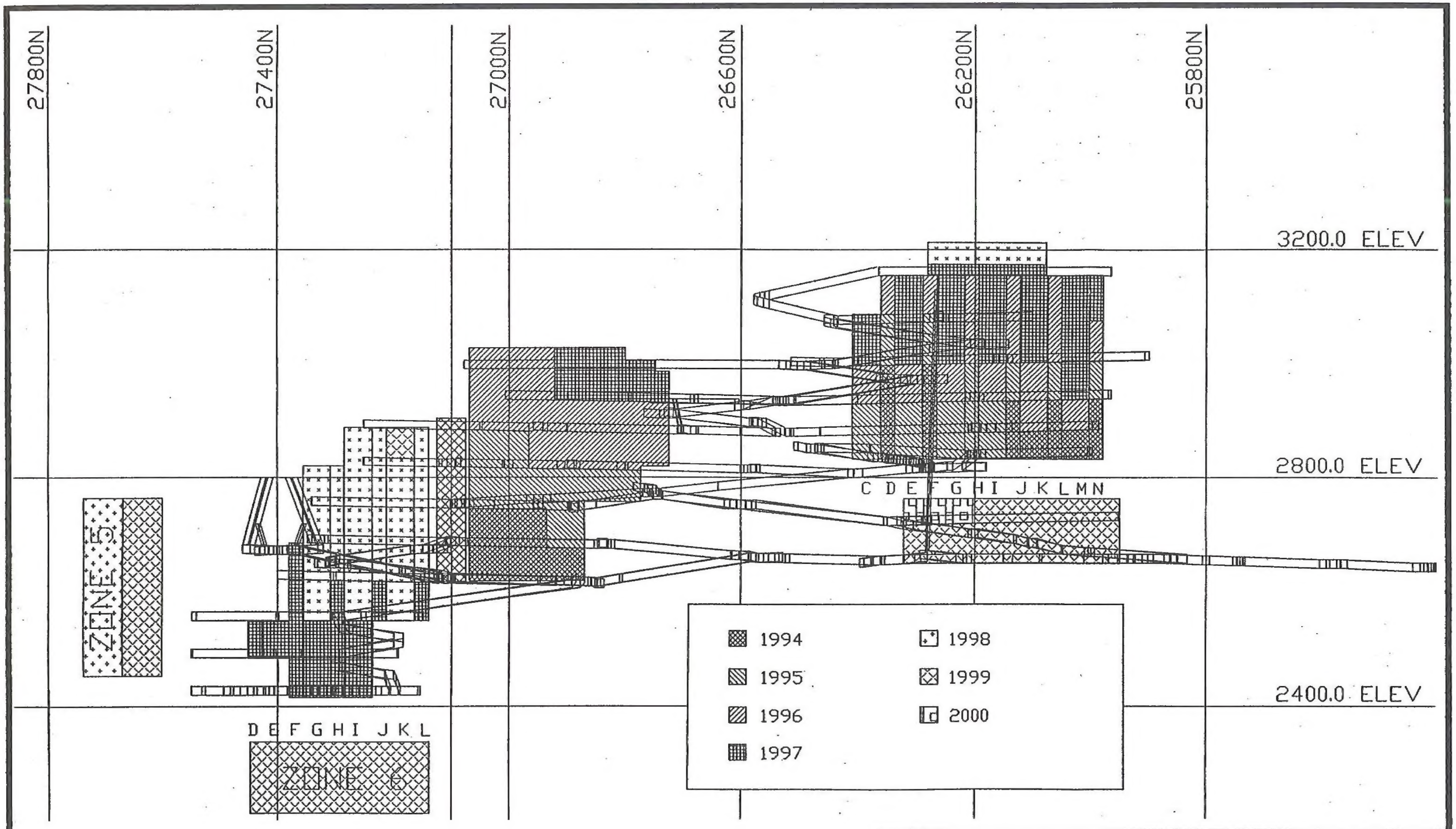
Source: Golder 1993

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

MINING SEQUENCE
LAMEFOOT PROJECT
LONG SECTION LOOKING EAST

FILE: 2-9A

DATE: NOV 19,93	SCALE:	FIG. NO. 2-9



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAMEFOOT PROJECT
LONG SECTION
LOOKING EAST

DATE: MAY 1994	SCALE:	FIG. NO. 2-10

LFSECE

2.3.3 Underground Mining

Underground commercial production at the Lamefoot deposit would consist of two primary methods of material extraction techniques. Access to mining areas and drifting (tunneling) in ore would be accomplished by the use of a jumbo drill and conventional blasting methods (Figure 2-11). A jumbo drill is a rubber tire mining machine which drills near-horizontal holes in a mining face to be blasted. This method results in drifts which can be driven on the level or on an incline, either up or down, of up to about 15% grade. Most ongoing development of mining areas during the commercial phase would be accomplished by this method.

The majority of the ore commercially extracted within the mining areas would be removed by a long hole open stoping technique (Figure 2-12). This method utilizes drill holes collared in one ore drift (sublevel) and drilled upwards or downwards toward the adjacent sublevel above or below or toward the ore boundary. These holes are loaded with explosives. The ore between the levels is blasted and falls into a lower level or to the bottom of the active stope, where it is removed. Drilling for blast holes would be done by a single boom production blast hole drill, an electrically operated machine specifically designed for vertical or angle holes. Draw point locations may vary from that shown on Figure 2-12 depending upon the stoping method to be used.

2.3.3.1 Stoping Methods

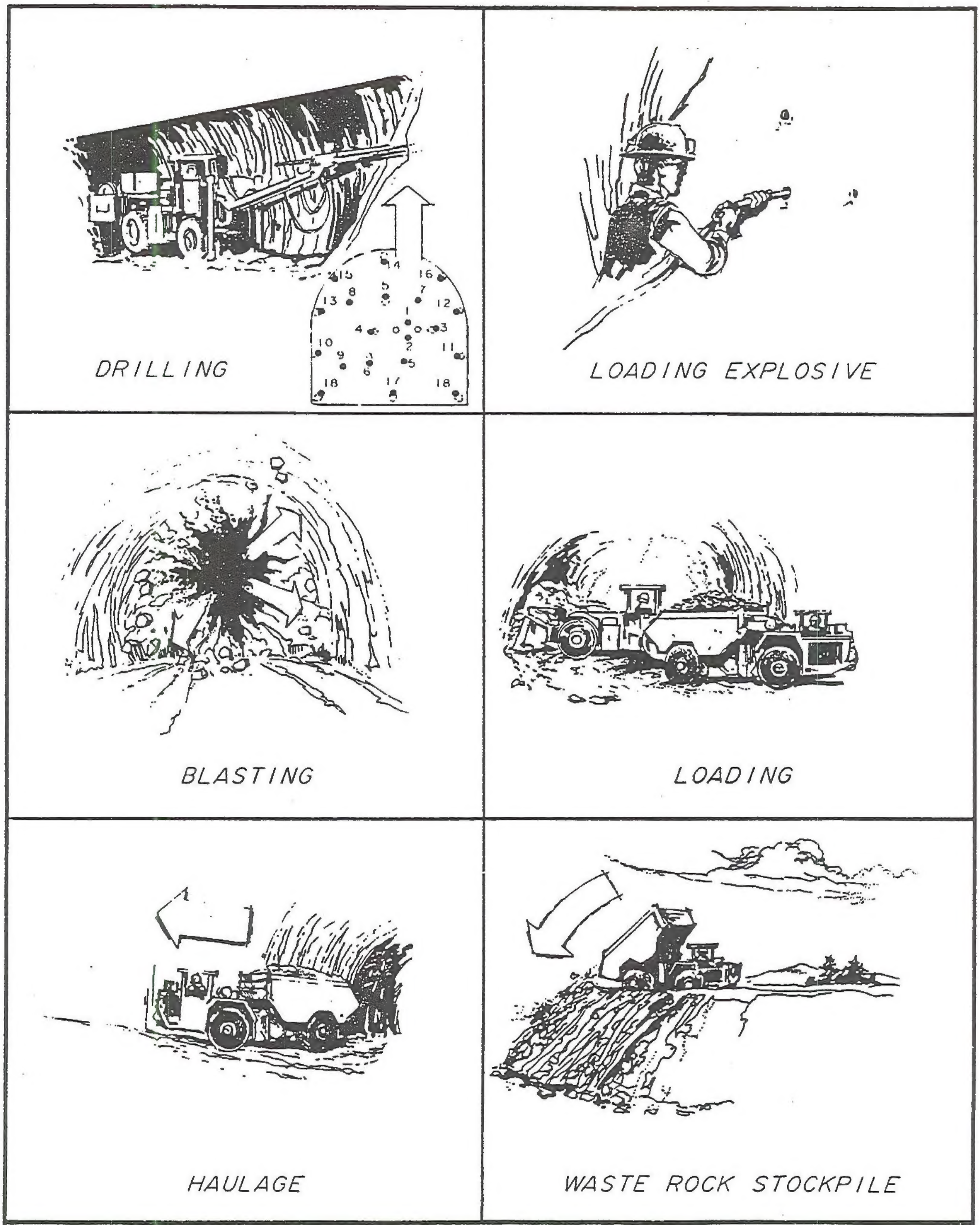
Stoping methods would be selected based on orebody dimensions and configuration. Echo Bay proposes to use the three stoping methods listed below (Echo Bay 1993b).

- Transverse stoping
- Longitudinal stoping
- Drift and waste fill

Specific backfilling procedures are proposed for each stoping method. Backfilling procedures are described in Section 2.3.3.4.

Transverse stoping would be used in Zone 1 and 6 and portions of Zones 2 and 4 where the orebody width is 60 feet or more. Stoping would be completed perpendicular to the strike of the vein, essentially in an east-west direction as depicted on Figure 2-13. The stoping process starts with development of primary stopes. These stopes would be approximately 24 feet wide and 65 feet high and would start along the base of the orebody. The centerline of each stope would be approximately 70 feet from the centerline of neighboring stope or stopes. The primary stopes would be backfilled with cemented rockfill which would be allowed to cure for approximately 30 days before continued development of the stope through the overlying ore materials. This development sequence would continue until the primary stopes reach the top of the orebody. As the primary stopes advance up through the orebody, the ore in the stope walls would be mined through development of secondary stopes. The secondary stopes would start at the base of the orebody and proceed upward sequentially in 65-foot increments to the top of the orebody similarly to the primary stopes. Each secondary stope would be approximately 48 feet wide and would be supported on each side by the pillars of cemented rockfill placed previously in the primary stopes. The secondary stopes would be backfilled with uncemented rockfill or waste fill to support the stope walls and form the floor for development of the overlying orebody.

Longitudinal stoping would be used in Zone 5 and portions of Zones 3 and 4 where the orebody is typically 60 feet wide or less. Stoping would be completed along the strike of the vein, essentially in a north-south direction as depicted on Figure 2-13. Each stope would be started at the base of the orebody and would progress upward in 65-foot-high increments until the top of the orebody is reached. The stopes would be



DRILLING

LOADING EXPLOSIVE

BLASTING

LOADING

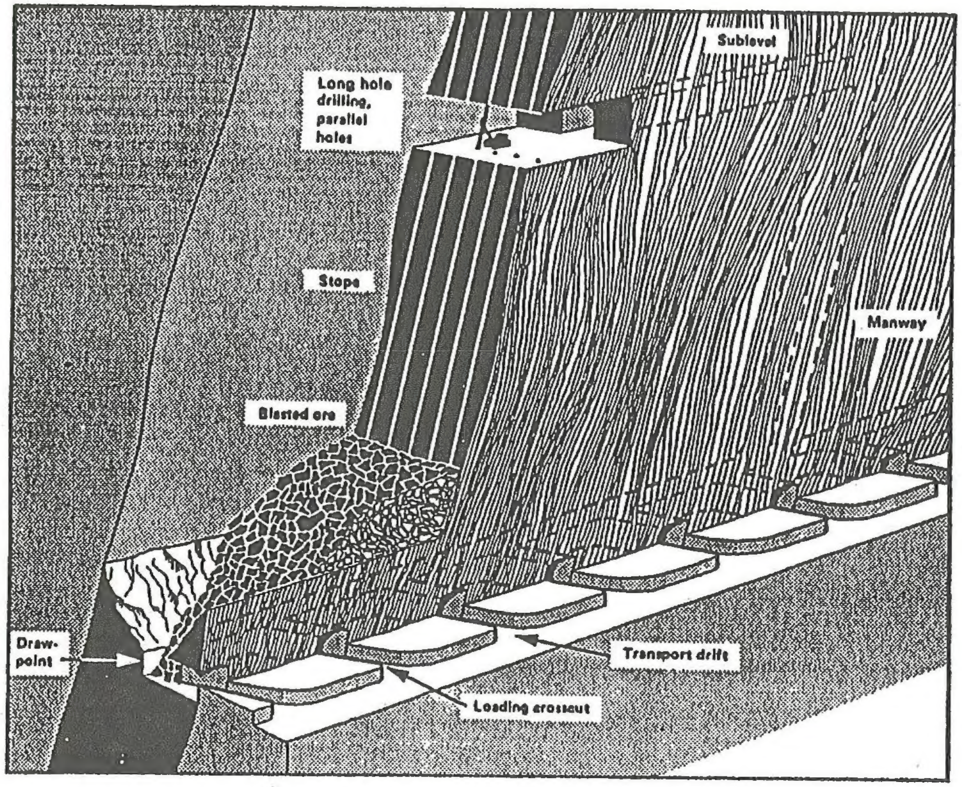
HAULAGE

WASTE ROCK STOCKPILE

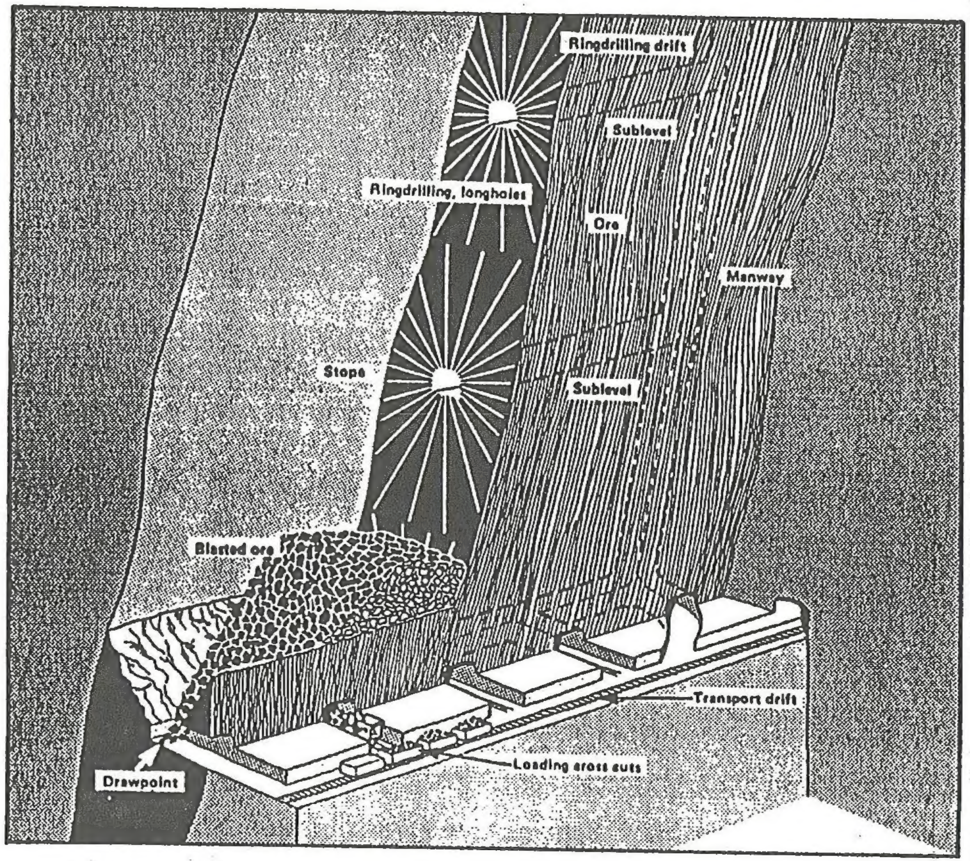
MINE DECLINE DEVELOPMENT TECHNIQUES

FIGURE 2-11

SOURCE: STATE OF WASHINGTON DOE 1988



Sublevel stoping with long-hole drilling and blasting.



Sublevel stoping with ring drilling as the primary means of breaking ore.

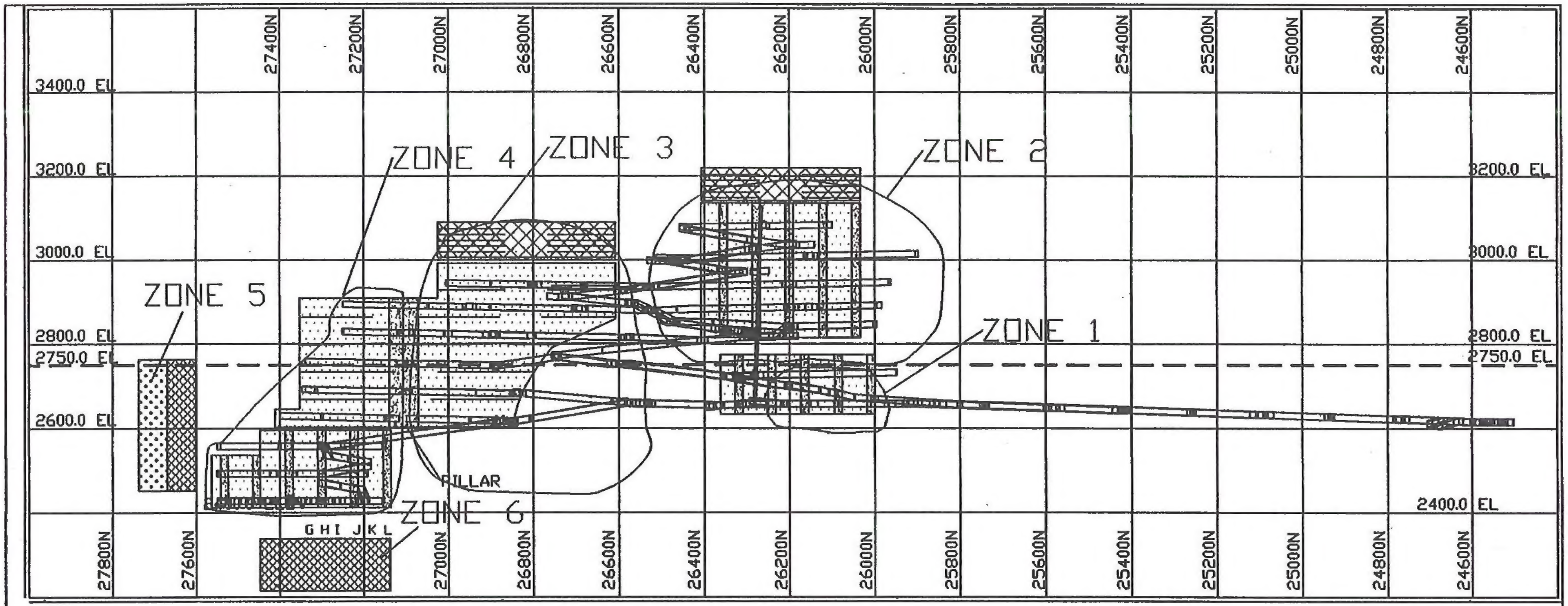
Source: Underground Mining Methods Handbook, Society of Mining Engineers, 1982.

CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

ECHO BAY MINERALS, INC.

TITLE
CONCEPTUAL DIAGRAM OF SUBLEVEL STOPING WITH LONG-HOLE AND RING DRILLING AND BLASTING METHODS
SOURCE: ECHO BAY 1993a

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE
	J.C.	L.E.C.	APRIL 1993	N/A		933-2614		2-12



▨ CEMENTED ROCK FILL

▤ LONGITUDINAL STOPING

▩ DRIFT AND WASTE FILL

▨ WASTE FILL

FILE: 2-12-1

ECHO BAY LAMEFOOT PROJECT

Source: Echo Bay 1993

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

STOPING AND BACKFILLING METHODS
LAMEFOOT PROJECT
LONG SECTION LOOKING EAST

DATE: NOV 19,93	SCALE	FIG. NO. 2-13

backfilled sequentially using uncemented rockfill (or waste fill) to support the stope walls and provide a floor for development of the overlying orebody.

Drift and waste fill methods would be used in portions of the upper Zones 2 and 3 as shown on Figure 2-13. Drifting would be completed along the strike of the vein, essentially in a north-south direction and would start on top of the previously backfilled stopes. Each drift would be developed to the full width of the orebody over the length of the stoping area. Following backfilling of the preceding drift with uncemented rockfill (or waste fill) to within a few feet of the back (or drift ceiling), another drift would be started over the backfilled drift. This sequence would be repeated until the top of the orebody is reached or surface disturbance criteria prevent further mining.

Echo Bay has indicated that although the mining and backfilling plans described in this document have been developed in detail and are final based on available information, some modifications are anticipated during implementation to suit local conditions as encountered in the field (Echo Bay 1993c).

2.3.3.2 Drilling and Blasting Procedures

Vertical and angle blast holes in the stope would vary in diameter from 2¼ inches to 6 inches and would be spaced from 5 to 15 feet apart. Water may be used during drilling to cool the drill bit and to wash the drill cuttings from the hole. This water would be obtained from sumps located throughout the mine. No drilling additives would be used with this water.

The holes will be loaded with an ammonium nitrate based explosive such as ANFO, water gel, or emulsion. Stick powder (dynamite) or cast boosters will be used. It is anticipated that emulsion will be the primary explosive material utilized based on ground conditions and the dry rock encountered to date. However, different rock types respond differently to the various explosives depending on lithology, degree of fracturing and alteration. In addition, drill hole sizes, spacing, and patterns also influence the blasting techniques. Blasting compounds and techniques will be adjusted as dictated by these variables. Echo Bay is currently experimenting with alternative explosives (see Section 2.3.5.2) such as emulsions to minimize nitrates in mine waters. If emulsions are found to be effective for nitrate control, the blasting alternatives will be limited by the use of this type of explosive. Approximately 1/2 lb of emulsion per ton of ore will be required for mining. Non-electric blasting caps will be the detonation devices for the explosives. Care will be taken in the handling of explosive materials to optimize safety of workers and minimize spillage of bulk materials.

Individual slices in the vertical plane of the orebody would be blasted into the open stope. The broken ore would be accessed below at draw points as shown on Figure 2-11.

After blasting and prior to entry, the mining area would be ventilated to exceed air standards prescribed by the Mining Safety and Health Administration. Exhaust air would be vented from the ventilation raise and the main exhaust crosscut (Figure 2-10). The ventilation raise was constructed as part of Phase I of the exploration program. The main exhaust crosscut is an existing adit dating from the early part of the century. Water sprays would be used to mitigate particulate emissions in the exhaust. Depending on final configuration of the mining areas, one or more ventilation raises or crosscuts may be needed to provide adequate air flow to the working areas, although Echo Bay does not propose any such facilities at this time.

2.3.3.3 Ore and Waste Transfer Procedures

Broken waste rock would be loaded into low profile diesel-powered underground haul trucks at or near the face (end) of the working headings (drifts), or at draw points for the stopes. Diesel-powered front end loaders with a six yard-rated capacity would be utilized along with the 26-ton capacity haul trucks. Initially, some of the waste rock would be hauled to the surface and deposited into the waste rock disposal areas as shown on Figure 2-6. Echo Bay estimates that 95 percent of the waste rock to be brought to the surface will be present at the end of exploration Phase II (Echo Bay 1993c). Little waste rock will be brought to the surface during commercial mining as most will be used immediately as backfill. Ultimately, most of the waste rock brought to the surface would be transported back underground and used as backfill material.

Stoped ore would be scooped and hauled from draw points at the lowest level of an active stope. In areas to be mined using the transverse stoping method the draw points would be located in the foot wall or hanging wall at the base of each vertical increment. Where longitudinal stoping is proposed the draw points would be located at the end of the working stope and remote controlled machinery would be required to safely excavate the broken ore. The ore would then be hauled to the temporary ore stockpile area shown on Figure 2-6. Ore would be sorted according to location on the stockpile area so that material from different ownership interests and lease agreements could be segregated and weighed separately.

2.3.3.4 Backfilling

To minimize overall surface disturbance on public land and to prevent adverse subsidence of the rock overlying the open stopes, selective backfilling of the void produced during mining would be done after individual stopes are completed. Rock would be hauled from the surface and dumped into the stope by the use of underground haul trucks. When a mining area's individual stopes are complete, backfill would be obtained from the existing waste dumps or the borrow area. A cement silo would be constructed on the surface and a batch plant would be installed underground for production of cemented backfill.

Two sources of rock would be used as backfill. The 250,000 tons of waste rock placed directly from underground development or from the surface disposal areas constructed during exploration and development would comprise part of the backfill material. Based on an estimated unit weight of 110 pounds per cubic foot (pcf) for backfill, the 250,000 tons of waste rock will form approximately 167,970 cubic yards of backfill or approximately 15.4 percent of the required total. The remainder would come from the borrow area associated with the county road relocation. Figure 2-8 shows a cross-section through the excavation and a filled stope in Zone 2.

The borrow area location was selected for the following reasons:

- proximity to the underground workings
- minimum visual impact
- existing borrow area site (previously disturbed)
- private property only
- availability of non-acid generating backfill

Some of the backfill used in areas to be developed using transverse stoping would be mixed with cement. Cemented backfill (or cemented rockfill) provides greater support than unconsolidated backfill. The need for cemented backfill would be determined by stope geometry and mining sequencing. The cemented rockfill would be made by mixing sized waste rock (6 inch maximum particle size) with Portland cement, water, a water reducing agent and possibly other suitable additives. In addition, fly ash is being considered for use in place of some of the cement. Following mixing, the backfill would be hauled by truck and end dumped into the empty stopes. As the backfill level rises within the stopes the fill would be bladed and leveled using a bulldozer to form the working floor for the next stope above (Echo Bay 1993b).

Uncemented backfill (or waste fill) would be hauled by trucks to the longitudinal stopes and the transverse secondary stopes and end dumped. This fill would be bladed and leveled by a D-4 or D-6 size bulldozer to form the working floor of the next stope above (Echo Bay 1993b).

Uncemented backfill in the drift and waste fill areas would be hauled by truck and dumped and pushed into place using a bulldozer. The fill would then be packed to within a few feet of the back.

Waste rock sizing is expected to be accomplished primarily through controlled fragmentation during blasting for pit development. Rockfill for uncemented backfill will be screened to remove fragments larger than 24 inches using a 24 inch grizzly. Cemented rockfill will be screened to remove fragments larger than 6 inches using 24 inch and 6 inch grizzlies above the cemented rockfill chute. If additional sizing becomes necessary an underground crusher will be installed in close proximity to the cemented rockfill plant.

The requirements for backfill in the Lamefoot mine would be determined by the total amount of ore mined throughout the mine life. If all current probable and possible reserves were mined out and all mined out areas were filled, approximately 900,000 bank cubic yards of backfill would be required. The area of potential excavation shown on Figure 2-7 could provide up to 1,000,000 cubic yards. The approximate area of disturbance would measure 17 acres. To minimize surface water runoff out of the quarry area, the benches that would form with the removal of material will be constructed to slope gently into the hillside, thus enhancing ponding and infiltration while reducing runoff. A detention berm would also be constructed to prevent runoff out of the quarry. Figure 2-8 shows a conceptual location for such a structure. The plan of operations for the Lamefoot mine would have design details for all aspects of quarry development.

The development of access points for backfill in individual stopes would be determined based on stope geometry defined during the exploration phase. The proposed action, allowing direct access from the borrow excavation, is depicted on Figure 2-8.

2.3.3.5 Mine Ventilation

Ventilation of the mine would be provided by electric fans. Fans draw air into the portal, and three fans (60 to 100 hp each) would exhaust air from the 6-foot diameter crosscut or ventilation raise (Figure 2-13). One 250-hp fan would exhaust air from the exhaust crosscut. Air flow and the routing of air to specific areas underground are facilitated by the use of strategically placed barriers to air flow, and the use of up to six 60- to 125-hp fans to blow air through a ventilation pipe or bag to working areas.

2.3.4 Additional Geochemical Characterization Program for Backfill and Wall Rock

To complement the planned activities described above, Echo Bay (1993d, 1994c) has an ongoing program for further geochemical characterization of quarried backfill, waste rock and wall rock materials during mining (see Appendix B and Sections 3.3 and 4.3 of this document). The goal of this program is to provide a database in a timely manner to assist with water quality evaluations and predictions during operations and post-closure. The program includes static and kinetic testing as necessary to evaluate the potential for these materials to produce acid rock drainage (ARD). This program is a continuation of previous efforts, which include acid-base accounting on limestone wallrock, intrusive wallrock and low-grade ore, kinetic testing of clastic wallrock and kinetic testing of quarried backfill.

Backfill quarry materials will be sampled at a frequency one sample per 10,000 tons. Given that the quarry materials to be backfilled total approximately 1,350,000 tons, 136 samples will be sampled for acid-production characteristics. The first 50 samples will be analyzed for Acid Generating Potential (AGP), Acid Neutralizing Potential (ANP), Net Neutralizing Potential (NNP), and Total Sulfur. Such results would allow estimation of the relationship between NNP and Total Sulfur. Once estimated, the remaining samples would be analyzed for Total Sulfur (%) only.

Underground waste rock will also be sampled at a frequency of one sample per 2,000 tons of waste rock. Since the percentage of waste rock will vary by area, the density of the holes sampled will also need to be adjusted by area. This would result in about 125 samples analyzed for Total Sulfur only (assuming approximately 250,000 tons of underground waste) over the 6-year life of the mine, at about 40 samples per year.

Ore and Waste Rock - Following mine closure, sediments from underneath areas where ore and waste rock piles have been stored on the land surface will be sampled to detect for possible metal, acid, or sulfate contamination to surficial materials.

In conjunction with the testing program, Echo Bay has installed additional groundwater monitoring wells in the vicinity of the orebody and between the orebody and Curlew Lake near the western property boundary. These wells will be used to monitor flow gradients and water quality in the areas. Locations of the wells were determined in conjunction with DOE and BLM and are shown on Figures 2-14 and 2-14a. Section 2.3.5, which follows, provides additional details.

Additional mitigation may be required by agencies in the ROD and water discharge permits developed following the EISS. Also, during operations, additional mitigation may be required over that already described in this section to deal with water quality issues. This mitigation will accommodate the results of additional testing accomplished during operations. These future requirements will be discussed with and approved by the Washington Department of Ecology and BLM.

2.3.5 Water Control, Monitoring, and Treatment

2.3.5.1 Water Handling and Routing in the Mine Workings

Expected water production and use for the proposed Lamefoot Project and other elements of the Kettle River operations are shown on Table 2-3. Based on these figures, Lamefoot water production is expected to exceed water demand at the mine (see Table 4.1-1 for additional details).

Water inflows to the Lamefoot Mine in particular, which are in excess of mine needs, would be pumped to the infiltration pond for discharge. If necessary, the water would be treated prior to discharge. At present, excess water is routed to a sump at the mine portal and discharged to the infiltration pond site shown on Figure 2-6. Other underground water will be used for drilling, washdown, and backfill cement mixing operations.

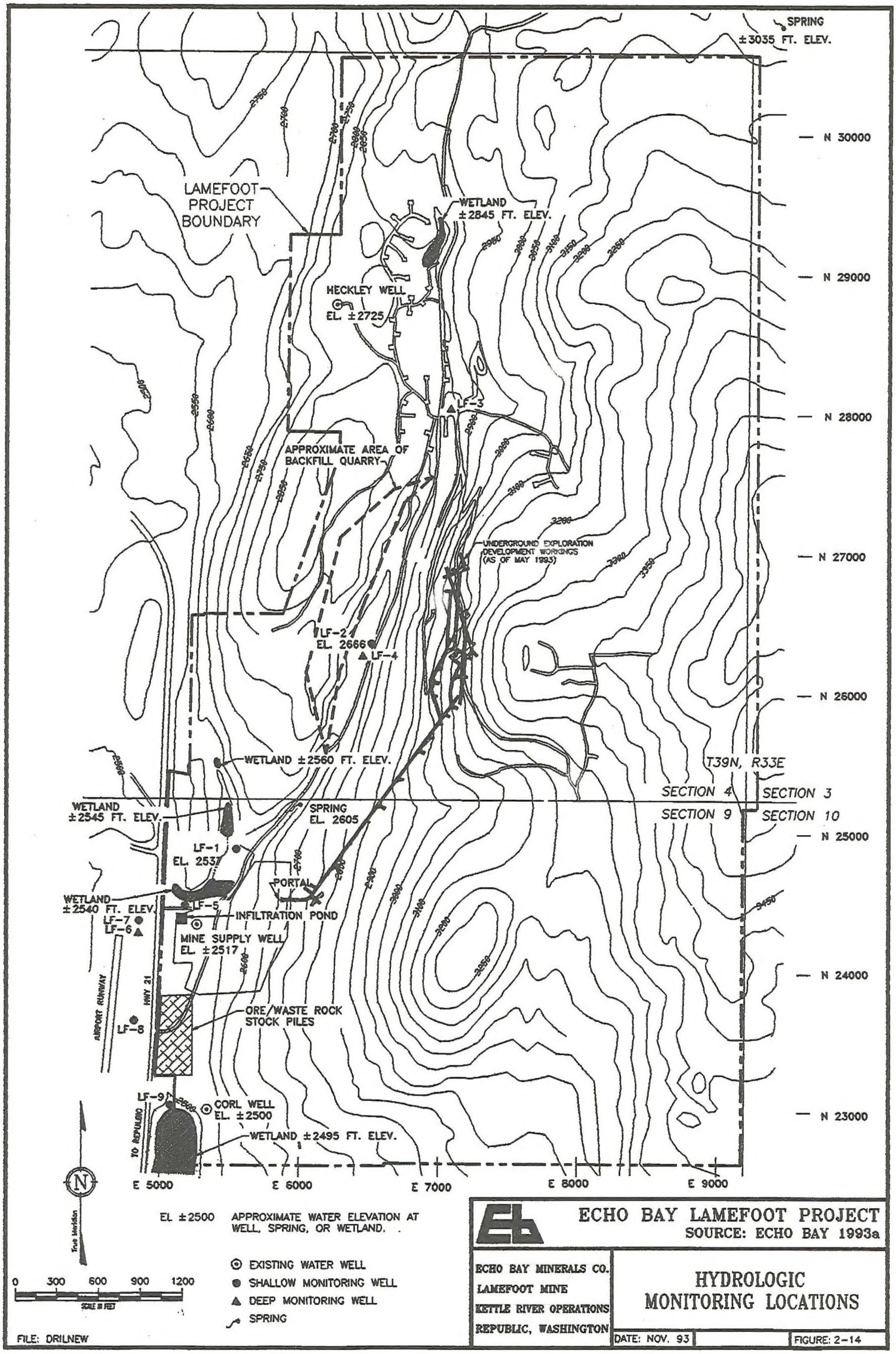
Echo Bay has proposed two initial actions to reduce potential seepage inflow to the mine (Echo Bay 1993d). The first consists of grouting of seeping drill holes, faults and/or fractures from the underground workings to reduce direct inflow. The second consists of diverting surface water flow around the area overlying the underground workings to reduce infiltration to the surrounding rock.

In sum, the measures undertaken to handle and route water in the mine workings will include:

1. Grouting drill holes, fractures, and seeps
2. Controlling mine infiltration by diverting surface water
3. Reusing mine water at the cement batch plant
4. Reusing mine water as makeup water for drilling
5. Reusing mine water for dust suppression within the mine

2.3.5.1.1 Underground Grouting Program. Echo Bay will perform drilling and grouting operations from the underground workings as necessary to reduce water inflow at points of substantial seepage. Grouting would be performed at locations where the workings intercept faulted or fractured zones of rock with inflows of 1 gpm or more.

The grout will consist of a variable mix of Portland cement and water with the possible addition of small amounts of powdered bentonite for fluidity. Pressurized injection of the grout mix into the fractured rock formation would be through drill holes or grout ports at the rock face. The number of drill holes and the quantity of grout to be injected at each location would vary depending upon the rock quality and the relative



EL ±2500 APPROXIMATE WATER ELEVATION AT WELL, SPRING, OR WETLAND.

- ⊙ EXISTING WATER WELL
- ● SHALLOW MONITORING WELL
- ▲ DEEP MONITORING WELL
- ↝ SPRING

ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1993a

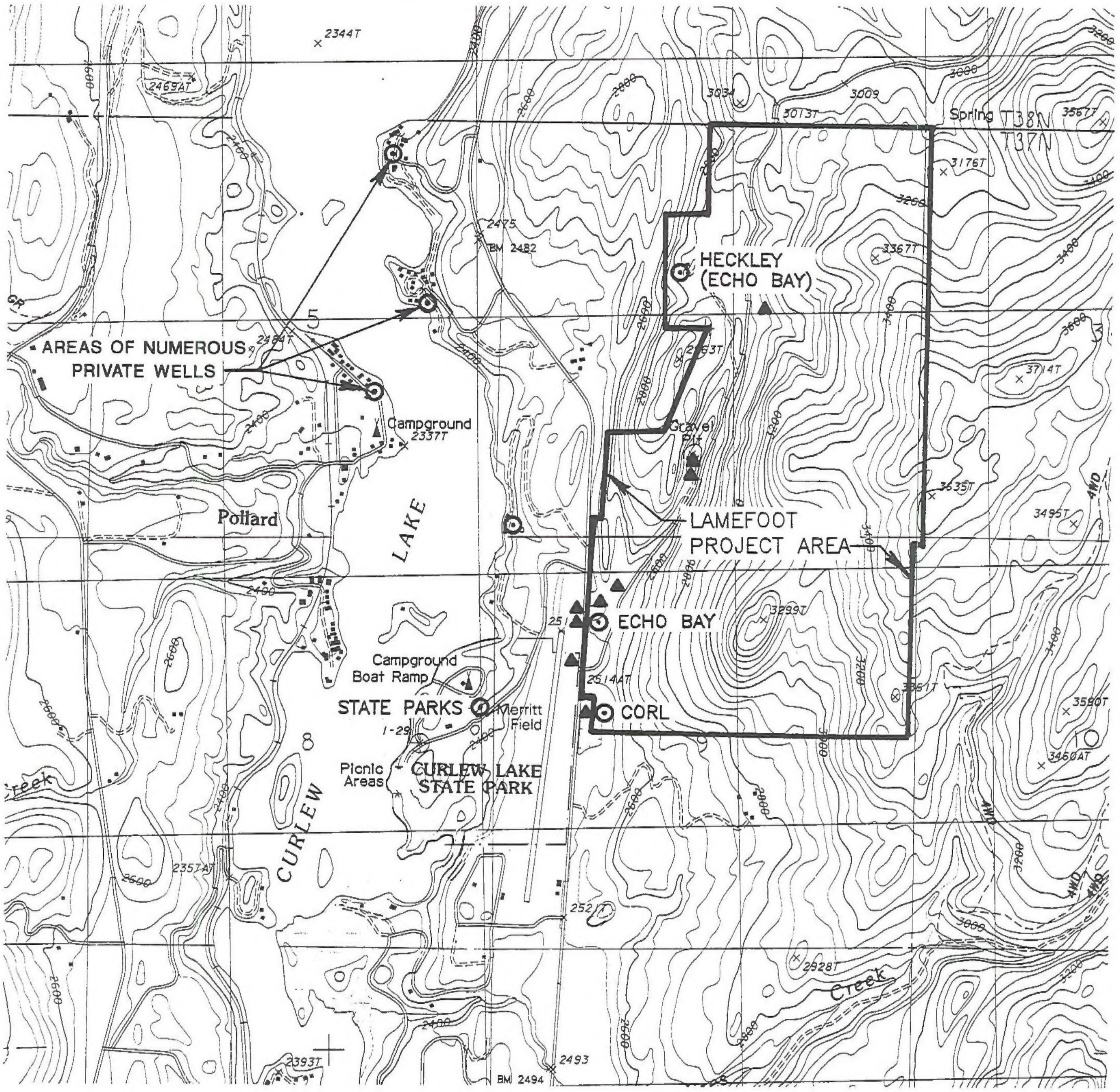
ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

HYDROLOGIC MONITORING LOCATIONS

DATE: NOV. 93

FIGURE: 2-14

FILE: DRILNEW



0 1000 2000 4000

SCALE IN FEET

WELLS WITHIN 1/2 MILE OF PROJECT AREA

⊙ WATER WELL ON FILE WITH WASHINGTON D.O.E. LOCATION TO NEAREST 1/4 SECTION AS INDICATED ON WELL LOG.

▲ ECHO BAY MONITORING WELL

ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

WATER WELL
INVENTORY MAP

DATE: JUNE 1994	SCALE: 1" = 2000'	FIG. NO. 2-14a

TABLE 2-3

PROJECT RELATED WATER PRODUCTION AND USE

Kettle River Project Component	Water Production and Use			
	Average Daily Consumption During Operations (gallons)	Consumption During Startup (gallons per minute)	Expected Range of Production Rate from Mine During Operation (gallons per minute)	On-site Storage Capacity (gallons)
Kettle River Mine	1,000 (from years 1988-1992)	N/A	0 to 15 Current: 0	2,000
Overlook Mine	2,000 (from years 1988-1992	N/A	0 to 10 Current: 0	0
Key East & West Mines	5,000	N/A	0 to 50	5,000
Lamefoot Mine Supply Well	2,000	N/A	0 to 64[a]	0 (small infiltration pond only)
Key Mill and Tailings Facility	70,000	600-700	N/A	5,900
K-2 Exploration	2,000	N/A	N/A	2,000

[a] See Table 4.1-1 of the DEISS for detailed estimates for Lamefoot project.

configuration of the faulted and/or fractured zones and the mine workings. The composition of the grout mixture will be selected to resist degradation under the geochemical conditions expected to occur in the foundations encountered during mining and post-closure.

2.3.5.1.2 **Surface Water Diversion**. Echo Bay will also reduce the potential for seepage into the underground workings by diverting surface water flows around the overlying hillside. A diversion ditch would be constructed along the alignment of the upper exploration road. (The exploration road locations are shown on Figure 2-2.) Diversion of surface water flows around areas overlying the underground workings would be expected to reduce infiltration into the workings and seepage into the workings.

2.3.5.2 Source Control

Echo Bay is also considering source control options within the mine to reduce the levels of nitrate and other analytes in mine water. As discussed elsewhere (see Section 2.3.3.2), low-solubility emulsion gel is being tested for blasting use, in contrast to the present ANFO explosives. Some combination of uses of these materials is expected to reduce nitrate levels during operations. Data from Echo Bay (1994b) show that nitrate levels declined in the sumps and infiltration pond from December 1993 to May 1994, as housekeeping measures were instituted to contain ammonium nitrate, and as pre-development blasting and ore sampling were curtailed March 1993.

2.3.5.3 Water Quality Detection and Treatment Contingency Program - Hydrologic Monitoring Plan Summary

This section and the next describe Echo Bay's commitments (subject to review by the DOE and BLM) to monitor underground water in the mine workings and at nearby monitoring wells, and to treat water of degraded quality should that become necessary. The concepts of this program are outlined, with a map drawing, in Recommended Mitigation for Geochemistry, Section 4.16. The following section further summarizes major points of the detailed Hydrologic Monitoring Plan (HMP) in the Plan of Operations, which provides the basis for the water quality monitoring and detection part of this program.

Permitted Discharge. Washington Department of Ecology (DOE) Waste Water Discharge Permit No. 8033 addresses monitoring at the Lamefoot Mine infiltration pond, Key Mill and Tailings Facility, and three other Key Project Mines. The Hydrologic Monitoring Plan (HMP) for the Lamefoot Mine incorporates the relevant monitoring and reporting requirements of DOE Waste Water Discharge Permit No. 8033 (i.e. Sections S2, S3, S4, and S7), as well as additional monitoring that has been required or recommended as mitigation measures by the Bureau of Land Management (BLM). These requirements were established through the processes of permitting the Lamefoot exploration activities and preparation of the Draft Environmental Impact Statement Supplement (DEISS) for the Lamefoot Project (BLM 1994).

The Hydrologic Monitoring Plan (HMP) addresses the monitoring and reporting activities throughout the operational period of the Lamefoot Mine. In particular, the HMP addresses the monitoring locations and sampling frequencies for mine water discharge, surface water (i.e. springs and wetlands), and groundwater at the mine site, as well as recordkeeping and reporting requirements. The HMP includes the following items, some of which are reproduced here as indicated:

1. Map of hydrologic monitoring locations (Figure 2-14)
2. Construction specifications for proposed wells
3. Aquifer testing procedures
4. Monitoring frequency (Tables 2-4 and 2-7)
5. Sample collection procedures
6. Chemical parameters and analytical methods (Tables 2-5 and 2-6)
7. Periodic interpretation of monitoring data (Section 2.3.5.5)

TABLE 2-4

LAMEFOOT MINE
HYDROLOGIC MONITORING PROGRAM DURING OPERATIONS

Sample Location	Flow	Water Level	Field Water Quality	Laboratory Water Quality[1]	Comments
Mine Water					
Underground Seeps	M		Q		Summed to estimate inflow
Portal	3/W				Totalizing meter installed
Infiltration Pond		3/W	3/W	M (O&G)	Weekly visual inspection; facility area
Surface Water					
Spring at 2605'	M		M	Q	V-notch weir installed
Spring at 3035'[2]	M		M	2B	N.E. of permit area
Wetland at 2495'		M	M		
Wetland at 2540'		M	M		
Wetland at 2545'		M	M		
Wetland at 2845'		M	M		
Groundwater Monitoring Wells					
LF-1 (shallow)		M	Q	Q	N. of infiltration pond and wetland 2540'
LF-2 (shallow)		M	Q	Q	N. along Wolfe Camp Road
LF-3 (deep)		M	Q	Q	N. of mine
LF-4 (deep)		M	Q	Q	W. of mine
LF-5 (shallow)		M	Q	Q	N. of inf. pond
LF-6 (deep)		M	Q	Q	W. of inf. pond
LF-7 (shallow)		M	Q	Q	W. of inf. pond
LF-8 (shallow)		M	Q	Q	W. of stockpiles
LF-9 (shallow)		M	Q	Q	S. of stockpiles
Private Water Wells					
Mine Supply Well (Echo Bay)		A	A	A	At mine surface facility pad near infiltration pond
Heckley (Echo Bay)		A	A	A	N.W. of mine
State Park[2]		A	A	A	Near Curlew Lake

Explanation of Symbols:
W = weekly
M = monthly
Q = quarterly
A = annually
2B = Two baseline samples to be collected during first year of monitoring

Water Quality Parameters:
Field = pH, conductivity, temperature

Laboratory = See parameter list on Tables 2-5 and 2-6.
(O&G) = Oil and grease analysis in addition to parameter list

[1] Long list of laboratory parameters to be analyzed for the first year of monitoring. During subsequent years the complete list will be analyzed once per year and the short list of parameters will be analyzed for the remaining samples (see Tables 2-5 and 2-6)

[2] This will be monitored if access can be arranged.

TABLE 2-5

PARAMETERS AND ANALYTICAL METHODS FOR WATER[1]
(METALS)

Parameter	Long List[3]	**Short List**[4]	Analytical Method[2] Recommended Method
Aluminum (Al)	X		EPA Method 200.7
Antimony (Sb)	X		EPA Method 200.7
Arsenic (As)	X	X	EPA Method 206.2
Barium (Ba)	X		EPA Method 200.7
Beryllium (Be)	X		EPA Method 200.7
Cadmium (Cd)	X		EPA Method 200.7
Calcium (Ca)	X		EPA Method 200.7
Chromium (Cr), Total	X		EPA Method 200.7
Copper (Cu)	X	X	EPA Method 200.7
Iron (Fe)	X	X	EPA Method 200.7
Lead (Pb)	X	X	EPA Method 239.2
Magnesium (Mg)	X		EPA Method 200.7
Manganese (Mn)	X	X	EPA Method 200.7
Mercury (Hg)	X	X	EPA Method 245.1 or 245.2
Molybdenum (Mo)	X	X	EPA Method 200.7
Nickel (Ni)	X		EPA Method 200.7
Potassium (K)	X		EPA Method 200.7
Selenium (Se)	X	X	EPA Method 270.2
Silicon	X		EPA Method 200.7
Silver (Ag)	X		EPA Method 200.7
Sodium (Na)	X		EPA Method 200.7
Thallium (Tl)	X		EPA Method 279.2
Zinc (Zn)	X	X	EPA Method 200.7

[1] NOTE: Samples for metals analyses will be analyzed for total recoverable metals. Selected samples may be field-filtered and analyzed for dissolved metals.

[2] EPA Methods are NPDES-approved, per 40 CFR 136 Tables: EPA 200 Methods from Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March, 1979, Revised March 1983.

[3] Long list of parameters to be analyzed during the first year of monitoring, then annually thereafter.

[4] **Short list** of parameters to be analyzed for the remainder of intervening sample intervals.

TABLE 2-6

PARAMETERS AND ANALYTICAL METHODS FOR WATER (ANIONS AND OTHERS)

Parameter	Short List[3]	Long List[2]	Analytical Method[1] Recommended Method
Alkalinity, Total, HCO_3/CO_3 and Hydroxide	X	X	EPA Method 310.1
Ammonia (NH_3) - as N	X	X	EPA Method 350.1
Chloride (Cl)		X	EPA Method 325.1
Orthophosphate		X	EPA Method 365.1, 365.2, or 365.3
Hardness		X	Calculated from Ca and Mg
Fluoride (F)		X	EPA Method 340.2
Nitrate (NO_3) - as N		X	EPA Method 300.0
Nitrate + Nitrite (NO_3 + NO_2) - as N	X	X	EPA Method 353.2
pH	X	X	EPA Method 150.1
Specific Conductance	X	X	EPA Method 120.1
Sulfate (SO_4)	X	X	EPA Method 375.4
Total Suspended Solids (TSS)	X	X	EPA Method 160.2
Total Dissolved Solids (TDS)	X	X	EPA Method 160.1
Oil and Grease[4] (O&G)	X	X	EPA Method 413.1

---

[1] EPA Methods are NPDES-approved, per 40 CFR 136 Tables: EPA 100 and 300 Methods from Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March, 1979, Revised March 1983.

[2] Long list of parameters to be analyzed during the first year of monitoring then annually thereafter.

[3] Short list of parameters to be analyzed for the remainder of intervening sampled intervals.

[4] Only Infiltration Pond will be sampled for Oil and Grease until post-closure monitoring begins.

TABLE 2-7

LAMEFOOT MINE PLANNED POST-CLOSURE HYDROLOGIC MONITORING PROGRAM

Sample Location	Flow	Water Level	Field Water Quality	Laboratory Water Quality[1]	Comments	Duration (Years)
Mine Water						
Behind Sealed Portal-approx. elev. 2610'		Q	Q	A (O&G)	300 ft. well required in backfilled workings.	10/30[2]
Deepest Workings - approx. elev. 2400'		Q	Q	A (O&G)	500 ft. well required in backfilled workings.	10/30[2]
Surface Water						
Spring at 2605'	Q		Q	Q	V-notch weir installed	10/30[2]
Wetland at 2495'		Q	Q			10
Wetland at 2540'		Q	Q			10
Wetland at 2545'		Q	Q			10
Wetland at 2845'		Q	Q			10
Groundwater Monitoring Wells						
LF-1 (shallow)		Q	Q	Q	N. of infiltration pond	10/30[2]
LF-2 (shallow)		Q	Q	Q	N. along Wolfe Camp Road	10/30[2]
LF-3 (deep)		Q	Q	Q	N. of mine	10
LF-4 (deep)		Q	Q	Q	W. of mine	10/30[2]
LF-5 (shallow)		Q	Q	Q	N. of inf. pond	10/30[2]
LF-6 (deep)		Q	Q	Q	W. of inf. pond	10/30[2]
LF-7 (shallow)		Q	Q	Q	W. of inf. pond	10/30[2]
LF-8 (shallow)		Q	Q	Q	W. of stockpiles	10
LF-9 (shallow)		Q	Q	Q	S. of stockpiles, if accessible	10
Private Water Wells						
Mine Supply Well (Echo Bay)		A	A	A		10/30[2]
Heckley (Echo Bay)		A	A	A	N.W. of mine	1
State Park[3]		A	A	A	Near Curlew Lake	1

Explanation of Symbols:
Q = quarterly
A = annual

Water Quality Parameters:
Field = pH, conductivity, temperature
Laboratory = see parameter list on Tables 9 and 10
O&G = Oil and Grease in addition to list

[1] Long list of laboratory parameters to be analyzed quarterly during the first year after closure, then once per year during years 2-10, and once per 2 years during years 12-30. The short list of parameters will be analyzed for quarterly samples during years 2-10.

[2] After initial 10-year monitoring, selected locations will be monitored once every two years from year 12 through year 30 after closure.

[3] If access can be arranged.

Standard operating procedures (SOPs) for equipment decontamination, drilling and well installation, aquifer testing, sampling, and documentation are part of the detailed HMP in the Plan of Operations. The SOPs were established to guide field personnel during the implementation of the monitoring program and assure the collection of consistent, reproducible, and defendable data.

(The water quality monitoring program by year for the life of the mine and post-closure is depicted graphically on Figures 2-14b and 2-14c, which are presented and described later in this subsection).

Table 2-4 presents the frequency for monitoring discharge, water levels, and water quality under the HMP. Tables 2-5 and 2-6 present the analytes and methods of laboratory analyses for the water samples to be collected. The long list of parameters will be analyzed for the laboratory sample locations and frequencies shown on Table 2-4 for the first year of monitoring. During subsequent years of monitoring the complete list will be analyzed once per year or as later agreed upon, and a "short list" of parameters (as indicated in bold on Tables 2-5 and 2-6) will be analyzed for intervening samples (e.g., quarterly samples).

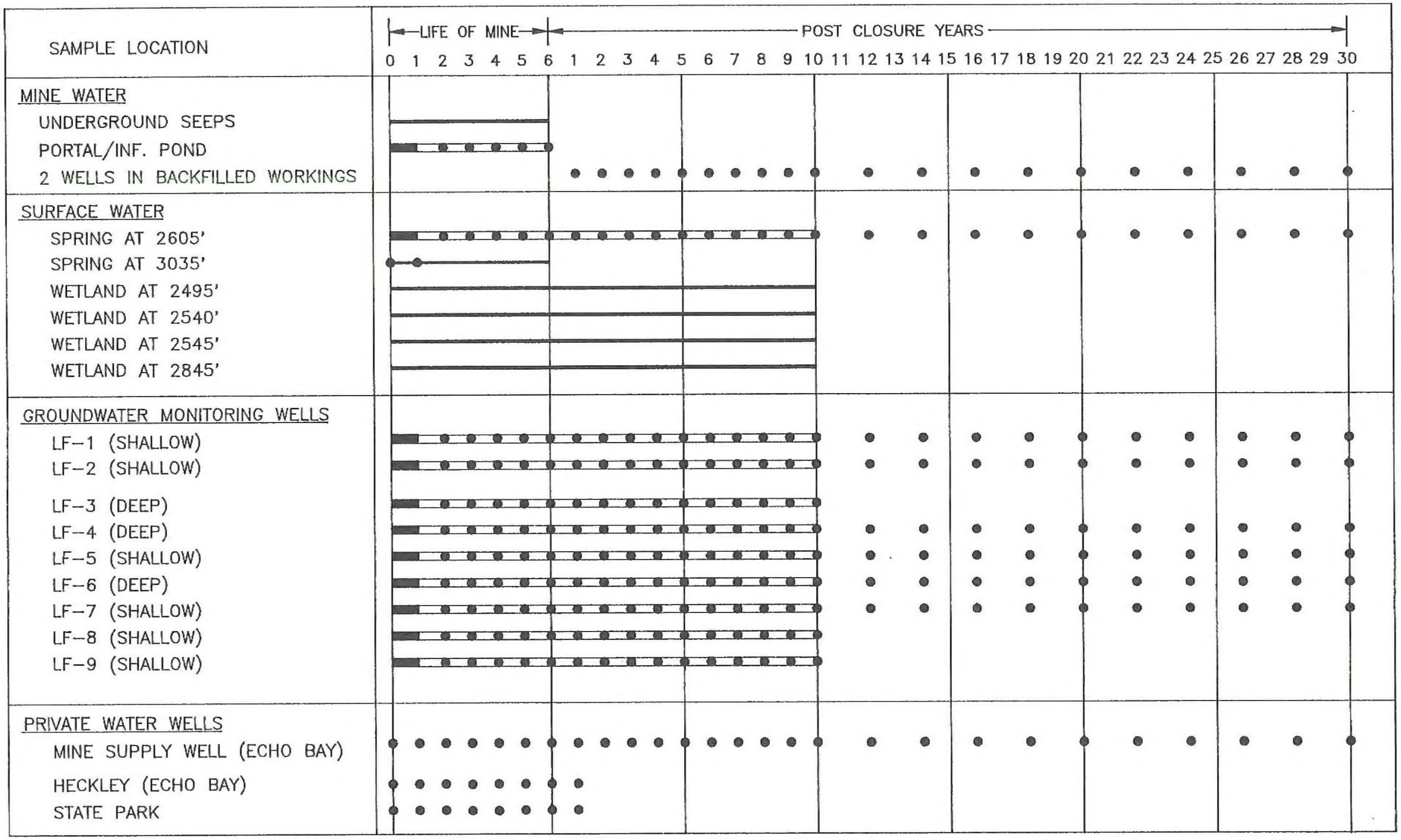
Mine Water. Mine water includes (a) water discharging as underground seepage into the mine, and (b) discharge of this water at the surface from the portal into the infiltration pond. Monitoring will consist of quantifying mine water discharge, and measuring field and laboratory water quality.

The amount of underground seepage into the mine will be monitored on a monthly basis during operations by Echo Bay. Estimates of flow from individual seeps will be summed to provide an estimate of total inflow to the mine. The monitoring of mine inflows will be used to identify any substantial (i.e., > 1 gpm) sources of inflow to be grouted for mine water control. Water quality monitoring will be conducted to identify whether any specific locations of degraded water quality inflows occur within the mine. Quarterly field water quality measurements from discrete inflow points of greater than 0.1 gpm will be noted by Echo Bay as needed for reporting purposes. Monitoring data from underground seeps will be recorded on a current map of the underground workings and also in tabular format. These maps will also note the location of grouted seep areas and the dates grouting was performed to help evaluate the effectiveness of the grouting program.

Mine water that is not used within the mine is discharged from the portal to the infiltration pond. This discharge is regulated by DOE Permit No. 8033, as discussed above. The portal discharge is intermittent, and is currently monitored using a totalizing flow meter. Meter readings and field water quality parameters will be recorded three times each week. During the periodic monitoring of the infiltration pond, the observed water level will be recorded and accumulated sediment will be removed as necessary to maintain the volume and infiltration capacity of the pond, as specified in DOE Permit No. 8033. Water quality measurements will be collected at the point of discharge to the pond if no water is present int he pond. Otherwise, the water quality measurements will be obtained by collecting a sample of the standing water in the settling or infiltration ponds. Samples will be collected monthly for laboratory water quality analyses. The samples collected will be analyzed for total recoverable metals, major ions, nitrate/nitrite, and total suspended solids (TSS). In addition to the listed parameters, water from the portal or infiltration pond will be analyzed monthly for oil and grease.

Surface Water. Surface water includes (a) water discharging from springs, and (b) water contained within the various wetland areas at the mine site. Surface water monitoring will consist of quantifying discharge and water levels, as well as measuring field and laboratory water quality. These measurements will be used to document natural variations in surface water quantity and quality, and to identify potential impacts of mining that may indicate the need for mitigation.

If possible, measurements of flow rate will be made monthly at two springs. One of the springs is located within the Wolfe Camp drainage at an elevation of 2,605 feet (Spring 2605), while the other spring is located northeast of the permit boundary at an elevation of 3,035 feet (Spring 3035). Visual observations of water conditions will be made monthly at four wetland areas. The wetland areas are located within the permit



EXPLANATION

▬	QUARTERLY OR MORE FREQUENT MONITORING/LONG LIST
▭	QUARTERLY OR MORE FREQUENT MONITORING/SHORT LIST
—	QUARTERLY OR MORE FREQUENT MONITORING/FIELD PARAMETERS
●	ANNUAL MONITORING/LONG LIST

ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1994

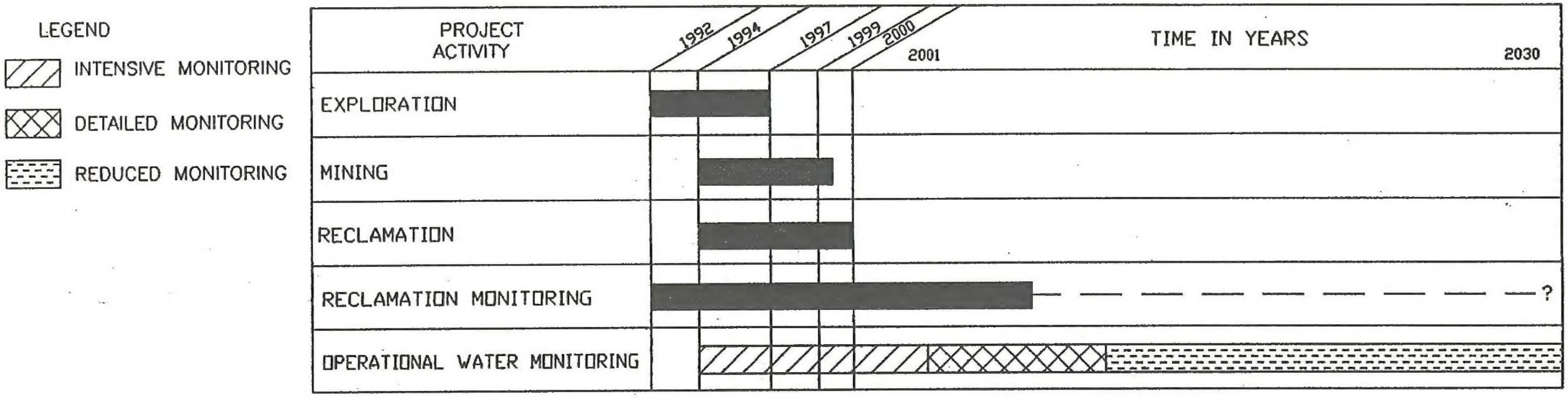
ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAMEFOOT MINE WATER QUALITY MONITORING BY YEAR

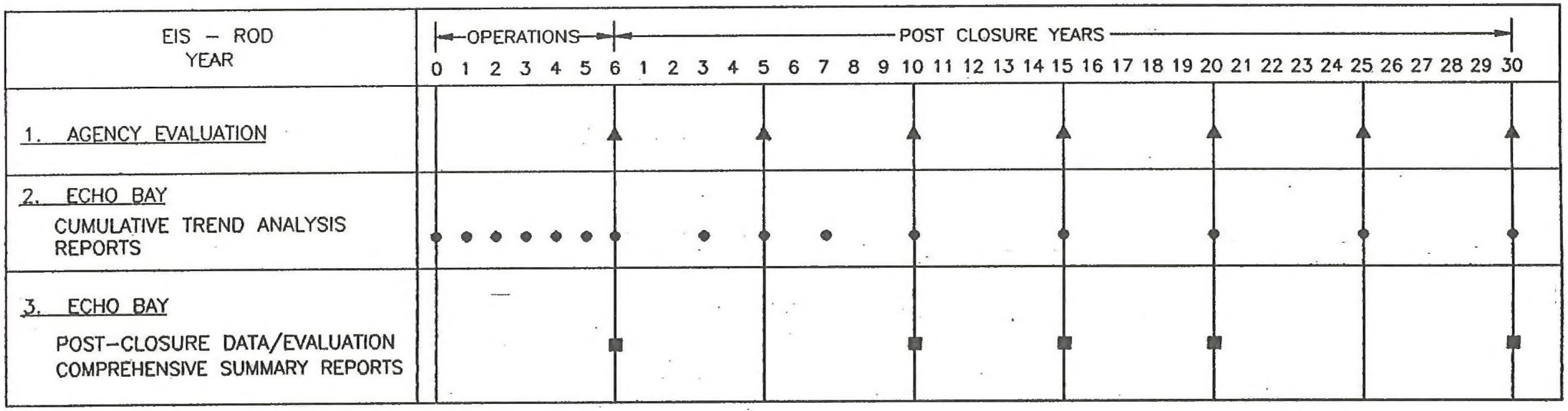
DATE: JUNE 1994 | SCALE: NA | FIG. NO. 2-14b

LAME214B

PROJECT SCHEDULE AND MONITORING PLAN



MONITORING EVALUATION SCHEDULE



NOTES:

1. ADDRESSES NEEDED CHANGES TO:
    - MONITORING PROGRAM (PROBLEM IDENTIFICATION, FUTURE ACTIVITIES)
    - BONDING REQUIREMENTS
    - FURTHER EVALUATION METHODS
2. CUMULATIVE TRACKING AND RECORD KEEPING OF INDICATOR AND OTHER PARAMETERS.
3. INCLUDE CUMULATIVE EVALUATIONS OF ANNUAL REPORTS FROM BASELINE TO PRESENT, AND CONCEPTUAL HYDROGEOLOGICAL/WATER QUALITY/GEOCHEMICAL EVALUATIONS.

ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAMEFOOT MINE
PROJECT SCHEDULE
AND MONITORING EVALUATION

DATE: JUNE 1994 SCALE: NA FIG. NO. 2-14C

LPS001

boundary at elevations of 2,845 feet (Wetland 2845), 2,545 feet (Wetland 2545), 2,540 feet (Wetland 2540), and 2,495 feet (Wetland 2495).

During the monthly visits to the springs and wetlands, field water quality measurements will be performed at each location, if possible. The purpose of this sampling is to establish a characterization of general water quality at these locations which can be used as a possible indicator for mining impacts. Samples for laboratory water quality analyses will be collected every quarter from Spring 2605, and will be coincident with quarterly sampling of groundwater monitoring wells. The purpose of this sampling is to monitor possible seasonal variations in water chemistry (which are naturally occurring), or variations which may have been induced from mining operations. In addition, laboratory water quality analyses will be collected from Spring 3035, if conditions permit. Two baseline samples will be collected (an initial sample and a confirmation sample) from this spring during separate sampling events. The purpose of this sampling is to document baseline water chemistry in the off-site spring, so that potential future mining impacts could be assessed, if necessary, at this location.

Groundwater. Conditions will be monitored in two existing monitoring wells, six new monitoring wells, one new well point and several existing private water wells as required by DOE Permit 8033 (see Figure 2-14a). This network of monitoring wells is designed to detect possible changes in water quality or water level (a) during operation and post closure of the mine, (b) from seepage through ore/waste rock stockpiles, and (c) from seepage below the infiltration pond. The following tasks are part of the groundwater monitoring program:

- Drilling, installation, and development of four new shallow monitoring wells
- Drilling, selective hydraulic testing, installation, and development of three new bedrock wells
- Groundwater level monitoring and sampling of the existing and new monitoring wells, and selected private wells.
- Post-closure, construction of a valve/drain pipe at the portal, and two monitoring wells into the workings

Three new monitoring wells (LF-5, LF-7, LF-8) and a monitoring well point (LF-9) have been installed within the shallow unconsolidated sediments. The approximate locations of these wells are shown on Figure 2-14. The purpose of these wells is to document natural variations in groundwater flow directions and water quality within the unconsolidated sediments, and to identify potential impacts from mining that may indicate the need for mitigation.

Three new monitoring wells (LF-3, LF-4, and LF-6) have been installed within the deep bedrock beneath the mine site. The approximate location of these wells are also shown on Figure 2-14. The deep wells will be used to further characterize the permeability, flow pathways, and hydraulic connection with shallow groundwater for baseline characterization, in addition to their use for monitoring water quality within the bedrock. Each borehole has been packer tested on 20-foot intervals to evaluate the hydraulic characteristics of discrete zones of the bedrock. Of most interest are zones of noticeable fracturing and faulting, because these zones are most likely to provide the pathways for the migration of groundwater through the bedrock.

Following completion of the packer tests in boreholes LF-4 and LF-6, constant rate pump tests were performed. These tests were performed to evaluate the average hydraulic characteristics of the bedrock aquifer; and to qualitatively evaluate the possible hydraulic interconnection between groundwater in the overlying unconsolidated sediments, and groundwater in the bedrock. During the tests, water was pumped at a constant rate, and water levels were monitored in the pumping well and in nearby monitoring wells for drawdown response.

Groundwater levels will be monitored on a monthly basis in the pre-existing and new monitoring wells. The purpose of this monitoring is to evaluate groundwater flow directions in the unconsolidated sediments and the bedrock, and to evaluate water level fluctuations which may be attributable to the seasons or mining operations. Water levels will also be monitored in private water wells prior to sampling.

The two existing shallow monitoring wells and seven new monitoring wells will be monitored quarterly for field and laboratory water quality parameters. This network of monitoring wells is designed to detect possible changes in water quality during operation and post closure of the mine, ore/waste rock stockpiles, and infiltration pond. Additionally, several private water supply wells will be monitored annually as part of the program. This monitoring will supplement the data obtained from the existing and new monitoring wells and will be used to identify any potential impacts to the private wells that may require mitigation.

Post-closure, internal detection monitoring system, will be installed to measure water volumes and quality within the plugged mine workings. This would involve two approaches:

- The main portal bulkhead will have a **drain pipe and valve** to allow removal of water quality samples if desired. This valve (likely including a drain pipe with screens, filter, gauges, and valves) could also be used if draining of the upper workings for initial water treatment becomes necessary. The pipe will be sized to allow for a maximum mine inflow/outflow of 125 gpm.

- In addition, **two monitoring wells** will be installed from the land surface above the workings and into the workings. One well would be constructed into the workings behind the portal plug, down to an elevation of approximately 2,600 feet above MSL. The second would be constructed into the deepest and more northern part of the workings, down to an elevation of 2,200-2,400 feet above MSL. The wells would be used for long-term monitoring within the backfilled mine workings (5-30 years post-closure). Present estimates indicate that it will take approximately 5 years after plugging for water inflow to reach an equilibrium level (at about 2,750 foot elevation).

Summary of Water Control, Monitoring and Treatment

Under the first phase of **Primary Level Measures,** Echo Bay proposes to control water sources within the mine. These measures would include:

- Grouting drill holes, fractures and seeps
- Controlling infiltration
- Reusing mine water at the cement batch plant
- Reusing mine water for dust suppression within the mine

As a second phase of Primary Level Measures, Echo Bay is testing source control options, which involve the use of low solubility blasting compounds (water gel and emulsion explosives) to reduce the levels of nitrates.

In the event the first two phases were unsuccessful at controlling nitrates, then water treatment would be considered.

In addition, a pretreatment option is being evaluated for control of other analytes (if necessary).

1) **Secondary Level Measures - External Detection** - Monitoring of the external wells and seeps are summarized on previous pages.

Echo Bay has committed to conduct monitoring, report these data, and take action as required by the conditions of any permits developed by the Department of Ecology, in conjunction with the BLM. Specific actions would be designed based upon the conditions occurring at the time and location of detection of a problem. Some examples of secondary mitigation actions may include additional grouting, surface water diversion mine, water management, or other source control techniques to control ground water inflows.

2) **Tertiary Level Measures - Water Treatment Contingency** - Echo Bay has commissioned the preparation of studies on several potentially appropriate water treatment technologies. The details of these studies are described in Section 3.13.5 of the October 1994 Revised Plan of Operations. Should permitted thresholds be exceeded at any of the Secondary Level sites, the appropriate regulatory agencies would consider the implementation of one or more of these treatment technologies. Specific treatment technologies at that time would need to be evaluated based upon the actual chemistry of the water detected in the monitoring system. Echo Bay will commit to implementing the technology appropriate to meet permit requirements (see Appendix A for a discussion of possible treatment alternatives).

Post-Closure Monitoring. In accordance with DOE Permit No. 8033, monitoring of groundwater, surface water, and/or mine water will be required following closure of the mine operations. The monitoring plan established at this time will change as a historical data base is developed which identifies the geochemical trends of these waters. The number and location of monitoring points and the types of analytes that will be required is dependent upon this information and upon Washington DOE requirements at the time of closure. The historical data will be able to indicate whether some monitoring points no longer require monitoring, or whether additional monitoring points or methods may be required.

The proposed monitoring network is expected to be sufficient for post-closure monitoring. An initial proposal for monitoring frequency is presented in Table 2-7. After 10 years of post closure monitoring, a selected number of sample locations would be monitored once every two years to detect long-term geochemical changes during years 12 through 30 after mine closure. This monitoring program is intended to ensure that no unnecessary or undue degradation occurs from the operations. As noted below, first annual (and later, periodic) reports will tally and summarize the analytical results.

The monitoring plan may be modified as necessary during operations or post-closure to take into consideration the historical monitoring data. Post-closure, the monitoring plan will outline the most appropriate monitoring locations, monitoring frequencies, and analytes for this period, along with appropriate reporting procedures. Monitoring water quality in the backfilled mine will be accomplished by sampling from two points within the mine workings after closure.

Recommended laboratory analyses of the samples indicated on Table 2-7 include the parameters listed on Tables 2-5 and 2-6. The complete list of parameters would be analyzed quarterly for the first year after mine closure. During subsequent years, the complete list will be analyzed only once per year (or every two years for biannual samples) with intervening quarterly samples analyzed for the "short list" of parameters as indicated on the Table 2-5 and 2-6.

Recordkeeping and Reporting. Recordkeeping and reporting will be in accordance with the requirements of DOE Permit No. 8033 and document procedures presented in the hydrological monitoring plan. Figure 2-14b summarizes the detailed water quality monitoring planned. All records of monitoring activities and results shall be retained for the operational life of the mine, should any further actions become necessary. Records and results will be kept in the files at the mine site.

Operational monitoring results will be reported to the Washington DOE and the BLM on a monthly basis. Reporting and filing will be in accordance with the requirements of DOE Permit No. 8033 (Sections S3 and S7). The report will present the tabulated measurements and the laboratory analytical results. In the case of post-closure monitoring, reporting frequency will coincide with the monitoring frequency. For example, quarterly monitoring and reporting would be performed during the first 10 years after mine closure based upon the schedule presented in Table 2-7. An annual or periodic interpretive monitoring report, according to Figure 2-14c, will therefore also present a discussion of monitoring data, water quality and quantity trends, and effectiveness of mitigation.

2.3.5.4 Water Treatment

Should the need for water treatment arise, a study has been completed identifying currently appropriate technologies. Other technologies may be considered as well. As noted above, see Appendix A for a detailed discussion of the water treatment options.

Other potential future water quality issues would be handled by Echo Bay in conjunction with either the BLM (during the ROD phase of the EISS) or the Washington DOE (during the water discharge permit review).

2.3.5.5 Water Quality Detection and Treatment Contingency Program - Hydrologic Monitoring Plan Interpretive Reports

The following summarizes how Lamefoot water monitoring activities are planned to be reported, and the subsequent agency use of these reports to manage the mining activities through the operations and post-closure periods. The present scenario assumes six years of operations and thirty years of post-closure monitoring and oversight. Regulatory oversight may be required for longer than or less than thirty years (post-closure), but this time-frame corresponds to what is often referred to as a "facility life." That is, thirty years is roughly the time limit through which useful predictions can be made for facilities of this type.

Data Reporting and Evaluation

Operations Phase

Figure 2-14c presents an overview of the proposed Evaluation Schedule of activities. The water resources monitoring that is the basis for these activities is summarized in Section 2.3.5.3.

It is assumed, for purposes of this discussion, that Operational data will be compiled by Echo Bay and delivered to the agencies (BLM and/or Wash DOE) within one month of receipt from the laboratories. These data will be analyzed quarterly for simple concentration trends (using graphs and summary tables) by Echo Bay. In most instances, the plots will include only indicator parameters - field pH and specific conductance, total alkalinity, nitrate plus nitrite, and sulfates (discussed below). An annual Cumulative Trend Analysis Report summarizing all of the indicator parameters and other water resources data (Tables 2-4 through 2-7) will be prepared by Echo Bay and its contractors and submitted to the agencies by the end of April following the year of monitoring.

Indicator parameter trends would also be related to natural "background" or baseline concentrations. The present understanding of baseline groundwater quality is limited and will be augmented with samples from the newly constructed wells discussed in Section 2.3.5. As shown on Figure 2-14b, annual data reports would be prepared each year during the Operations Phase.

Post-Closure Phase

Echo Bay will prepare periodic Data/Evaluation Comprehensive Summary Reports, following the annual or periodic Cumulative Trend Analysis Reports discussed above, as shown on Figure 2-14c. These reports will be submitted to the agencies within five months of mine closure, and within five months after the end of post-closure years 3, 5, 7, 10, 15, 20, 25, and 30. The Comprehensive Summary Reports would include cumulative summaries of the annual report data and any other pertinent data, from pre-mining through the current reporting year. These reports would also include updated discussions and, if necessary, additional analysis and interpretation of site conceptual hydrogeology and water quality trends. Additionally, the reports will include recommendations of the need for geochemical modeling considering the current monitoring results and other factors.

Agency Evaluation

The agencies (BLM and/or Washington DOE) will use the Annual and Periodic Post-Closure reports to: (1) evaluate the effectiveness of the primary and secondary monitoring programs; (2) suggest any needed changes in these programs - i.e., additional wells or abandonment of wells, changes in monitoring frequency, other parameters; (3) evaluate the need for other mitigation activities - i.e., additional grouting, water diversions, or water treatment; and (4) determine the appropriate increases, decreases, or release of financial guarantees and/or changes in criteria for financial guarantee requirements. Upon review of the early Post-Closure Data/Evaluation summary reports, the agencies could direct that future Post-Closure Reports include simulations of future groundwater flow and transport, as well as geochemical modeling.

2.3.6 Power/Water Requirements

Electrical power is purchased from the Public Utilities District of Ferry County. Current power consumption is about 11,000-20,000 KW hrs/day at a rate of approximately $260,000-$470,000 per year. During production, the requirements would be about 20,000-25,000 KW hr/day. A substation at the site steps down the power from the Public Utilities District distribution line to 4.16 kV. A smaller substation at the portal further reduces voltage to 480v.

Water requirements for Lamefoot and other elements of the Kettle River operations are shown on Table 2-3.

2.3.7 Waste Rock Disposal Area

The waste rock disposal areas are located near the mine portal as shown on Figure 2-6. The existing waste rock piles contain material generated during the Phase I and Phase II exploration activities. Echo Bay anticipates that some additional waste rock will be added to these piles during completion of Phase II exploration and during startup of the commercial mining operation. The additional materials would be added to the top of the piles without significantly altering the existing waste footprint. Echo Bay projects 260,000 tons of waste rock in the surface piles at the end of Phase II exploration, representing approximately 95 percent of all waste to be brought to the surface during the life of the mine. Transport of waste underground for use as backfill will commence early in the commercial production phase. The remaining waste rock will be placed directly as backfill in the underground workings. Total waste rock tonnage is estimated to be 350,000 tons over the life of mine, assuming that no additional mineralization is located and that all currently indicated mineralization is mined (Echo Bay 1993c).

At Lamefoot, development drifting has been designed specifically to occur in limestone to the extent possible. This limestone is a highly neutralizing rock type, and a relatively small percentage of the development waste may be potentially acid generating. Approximately 30,000 tons of limestone were used as a base for the Waste Stockpile No. 3. The entirety of Waste Stockpile No. 1 and 2 are composed of limestone. Potential acid rock mitigation alternatives for both the underground workings and surface waste rock disposal areas are presented initially in the Lamefoot geochemistry characterization report (Appendix B) and refined in Sections 4.3 and 4.16-3.

2.3.8 Ore Transportation

The ore would be temporarily stockpiled at the Lamefoot site and then loaded into highway haul trucks by a front end loader for transportation to the mill. These trucks would probably be rated at a 20-ton capacity and would trail a 10-ton or 20-ton "pup," or tandem trailer. All trucks would conform to requirements of the Washington State Department of Transportation and the Ferry County Road Department, and would be permitted by the agencies if and as required.

The primary route for the haul trucks would be south along the two-lane State Highway 21 to the County Old Kettle Falls Road (formerly known as Cooke Mountain Road) then east to the Jack Mays Pride Road. The ore would be hauled on Jack Mays Pride Road to Fish Hatchery Road then east to the Key Mill (Figure 1-2). A one-way trip for the ore haul would include a total of 5.0 miles of state highway and 3.8 miles of county road. This is the longest of the potential routes considered. Its use would increase fuel consumption and vehicle emissions, but would utilize the upgraded road surface under construction in 1992-93. This alternative is preferred by the Ferry County Road Department and the County Commissioners. A road maintenance agreement between Echo Bay and the County provides for economic support in the costs of upkeep of the road. Echo Bay has also contributed funding for the reconstruction of the County road. Improvements of the Old Kettle Falls Road to be completed in 1993-94 would allow for year-round (all-weather) usage.

During commercial production, ore hauling would range from 30 to 70 round trips per day, depending on the truck size and actual production rate at a given time. The ore haul would be restricted to twelve hours per day between the hours of 6:30 a.m. to 6:30 p.m., seven days per week unless road conditions during the day require night haulage. Proposed and actual ore haul rates for the Lamefoot Mine and other Kettle River Project mines are summarized on Table 2-8. The proposed Lamefoot haul rates would be in effect for the life of the mine as defined in Section 2.3.2.

Public access to the Key Mill is also provided via an existing county road (Fish Hatchery Road). This route is not proposed for mine-related traffic, but is used by employees going to and from work.

2.3.9 County Road Relocation

The primary access to the Lamefoot site is the previous alignment of old Wolfe Camp Road (Figure 2-6), which was vacated by the County on January 11, 1993. The relocated Wolfe Camp Road (see "county road diversion," Figure 2-6) provides access to residences to the north. The backfill quarry is designed in part as a highway road cut, and will also include provisions for future use as a quarry by the County Road Department for construction aggregates. It is further planned to realign Wolfe Camp Road (see Fig. 2-7) to the west side of the small valley which the County road now occupies. This relocated alignment would largely occupy a previously disturbed area in the quarry. Some new surface disturbance (7.4 acres) would occur on private land as a result of this relocation.

A portal would be built next to the current county road so that material excavated from the quarry can be hauled underground for placement as backfill. This backfill may or may not require crushing, depending on the size reduction experienced during blasting. The quarry would be developed selectively to maximize production of neutral to basic (non- acid generating) rock, while minimizing production of rock with significant potential for acid generation (Echo Bay 1993c). Cement storage facilities would be constructed on the surface and underground. An underground batch plant would be required for preparation of cemented backfill.

TABLE 2-8

KETTLE RIVER MINES PRODUCTION AND KEY MILL TAILINGS CAPACITY

Mine Source	Haul Rate Tons/Day				Mill Throughput (000s tons)			
	1988 Proposed	1992 Proposed	1993 Actual	1994 Proposed	1988 Proposed	1988 to 1993 Actual	1994 Proposed	1995-2000 Proposed
Overlook Mine	1,000-1,500	1,200	0	0-600	Not specified	1,581	300	0
Kettle River Mine	300-500	0	0	0	Not specified	245	0	0
Key East/Key West Mine	0	2,000	2,500	0	0	597	270	0
Lamefoot Mine	0	0	150	1,200-2,000	0	85	876 to 1,460	803 to 1,390
K-2 Prospect	0	0	0	0	0	0	0	400 to 900?
Tailings Capacity					7,000	2,544/3,700	6,700	6,700
Total Capacity, Conceptual Design					9,600		9,600	9,600

2.3.10 Reclamation

Reclamation activities would include reclamation of surface disturbance and underground workings. Reclamation of drill site and access roads would be continued using the methods described in the approved Plan of Operations (see Appendix E). Surface disturbance associated with underground exploration and underground disturbance would be reclaimed at closure.

Surface reclamation activities would include removing structures, regrading, ripping, topsoiling, seeding, fertilizing and control of noxious weeds to ensure the establishment of desirable plant communities. The purpose of these activities would be to re-establish pre-mining drainage patterns and provide a stable surface and topographic conditions compatible with the surrounding landscape.

Reclamation of underground workings would be by backfilling the stopes. In addition, all surface openings including the main portal, the borrow area portal, and ventilation shafts would be plugged (Echo Bay 1993c).

2.3.11 Exploration Activities

2.3.11.1 General

An exploration program at the Lamefoot site has been ongoing since 1989 on both private and federal land. A Notice of Operations for exploration was initially submitted to the BLM in September of 1989 for surface drilling on federal land. Several modifications were made to that notice and, in 1992, a Plan of Operations (Golder 1992b) was submitted in anticipation that surface disturbance would exceed five acres on property managed by the BLM.

As part of the scope of the Plan of Operations (Golder 1992b), an underground exploration project was designed to confirm the results of surface drilling, establish feasibility of commercial production of gold ore, and obtain bulk samples of the ore for processing studies. That initial underground program was considered together with to the surface drilling program and was addressed in an Environmental Assessment (Golder 1992c) supporting the Plan of Operations (Golder 1992b). All of the surface disturbance associated with the underground exploration program has been confined to private land. The underground exploration program is currently in progress.

2.3.11.2 Previous Work and Ongoing Activities

From 1989 to 1992, extensive surface drilling was conducted at the Lamefoot Project by reverse circulation rotary and coring techniques. Exploration drilling occurred throughout the land holdings but focused on the primary area of mineralization in a zone about 1,500 feet long and up to 140 feet wide. A total of 280 holes were drilled on the surface of which 59 are located on federal land.

Roads were built to accommodate access by drilling equipment and support vehicles. All of the surface disturbance to date on federal land is associated with this drilling program. Figures 2-1 and 2-2 show the location of existing drill roads on public and private land. A detailed description of these roads and the drilling can be found in the Plan of Operations (Golder 1992b) and EA (Golder 1992c).

Currently, the Lamefoot deposit is being explored, assessed and developed by an underground exploration/development program consisting of two phases. Phase I, which has already been completed, includes the following elements:

- Development of surface facilities to support the underground activities
- Development of a tunnel to access the ore deposit

- Development of four levels along the mineralized body
- Development of a ramp to interconnect the different levels
- Development of a ventilation raise to the surface
- Development of crosscuts and raises along the ore to establish lateral and vertical continuity of the mineralization
- Providing working space and facilities necessary for normal development operations
- Processing of some or all of the mined ore for metallurgical study

Figure 2-15 shows an oblique view of the completed Phase I underground program.

Phase II is currently being implemented to further explore, delineate and develop specific areas of the mineralized body in preparation for commercial mining. The primary elements of Phase II are:

- Development of two additional levels in between initial drifts on ore
- Development of access drifts

Figure 2-16 shows an oblique view of the completed exploration and development after Phase II. Figure 2-17 shows the same oblique view delineating only the underground workings located on BLM land.

Based on information currently available, the total material extracted during the Phase I and II underground exploration program will be approximately 260,000 tons of waste rock and 114,000 tons of ore.

Additional exploration will be conducted for extensions of the known mineralization and for new deposits in the immediate area. This exploration will use both drilling and drifting underground and may require drilling from the surface. Underground exploration will be conducted by extending existing workings toward prospective areas. Underground core drilling will test these target areas with electric/air powered drilling rigs. These programs of underground exploration are likely to continue through the commercial mining phase until mine closure.

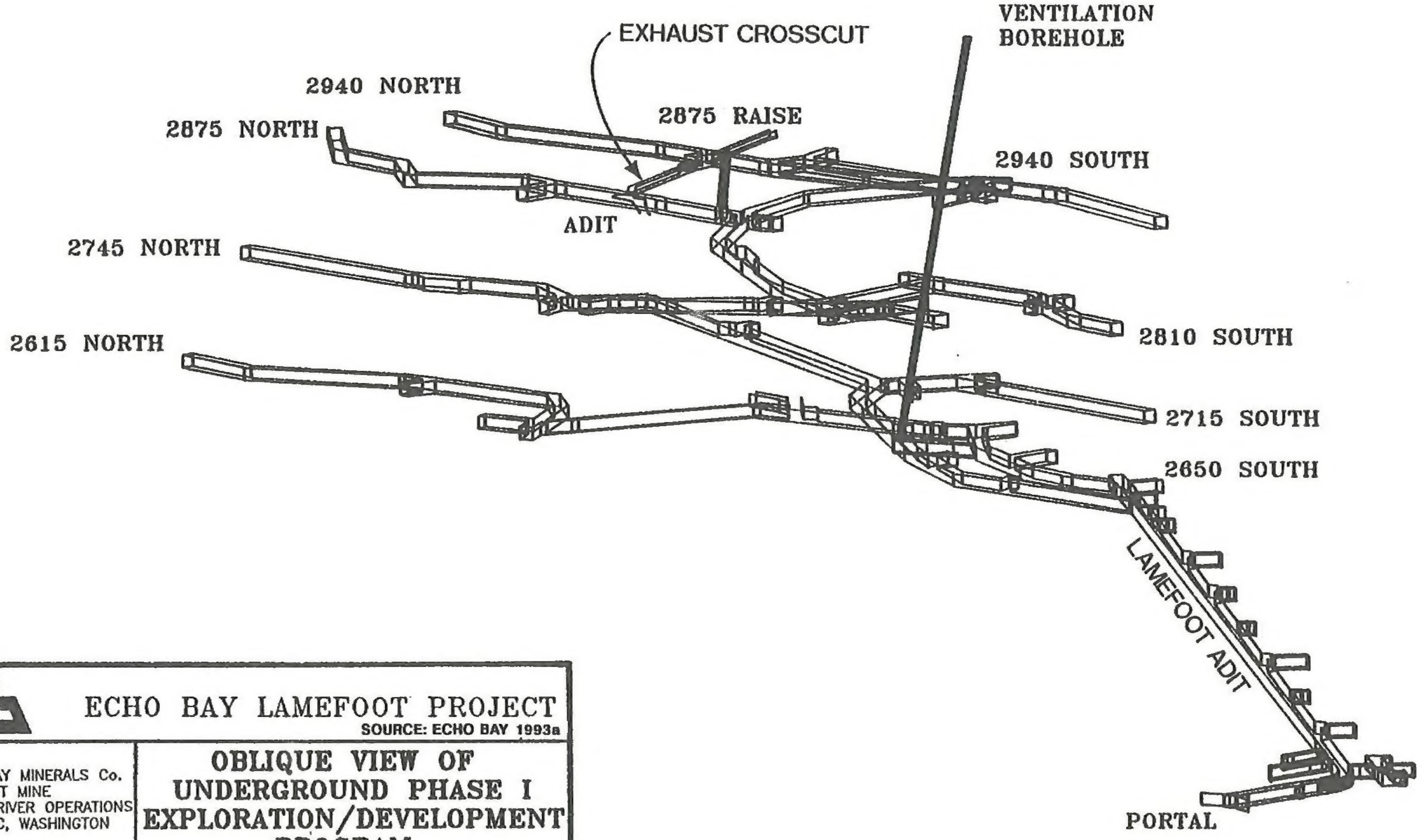
It is possible that additional surface exploration drilling may be warranted within the areas shown as BLM and private lands on Figure 1-3. Also, additional (infill) drilling of shallower portions of the previously defined deposit may be required to better delineate ore boundaries or to study geotechnical characteristics of the ore and host rock.

The general principal for access is to keep new disturbance to a minimum by using cross-country travel or helicopter supported drilling where appropriate. New drill pads may be constructed as necessary for access by the drill rigs. Any new roads will be constructed and reclaimed by methods discussed in the Lamefoot Plan of Operations (Echo Bay 1993a). The exact location of new roads will be determined by the location of the target to be drilled. These locations will be established based on results of the exploration and production phases.

2.3.11.3 Existing Surface Facilities

Site surface infrastructure consists of an office, shop, dry (change house), core storage facility, supply storage area and parking. Services include an electrical substation, compressor, two water wells and a septic field. Also present at the site are waste rock disposal areas, an infiltration pond and topsoil stockpile areas.

ELEVATED VIEW LOOKING NORTHEAST



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

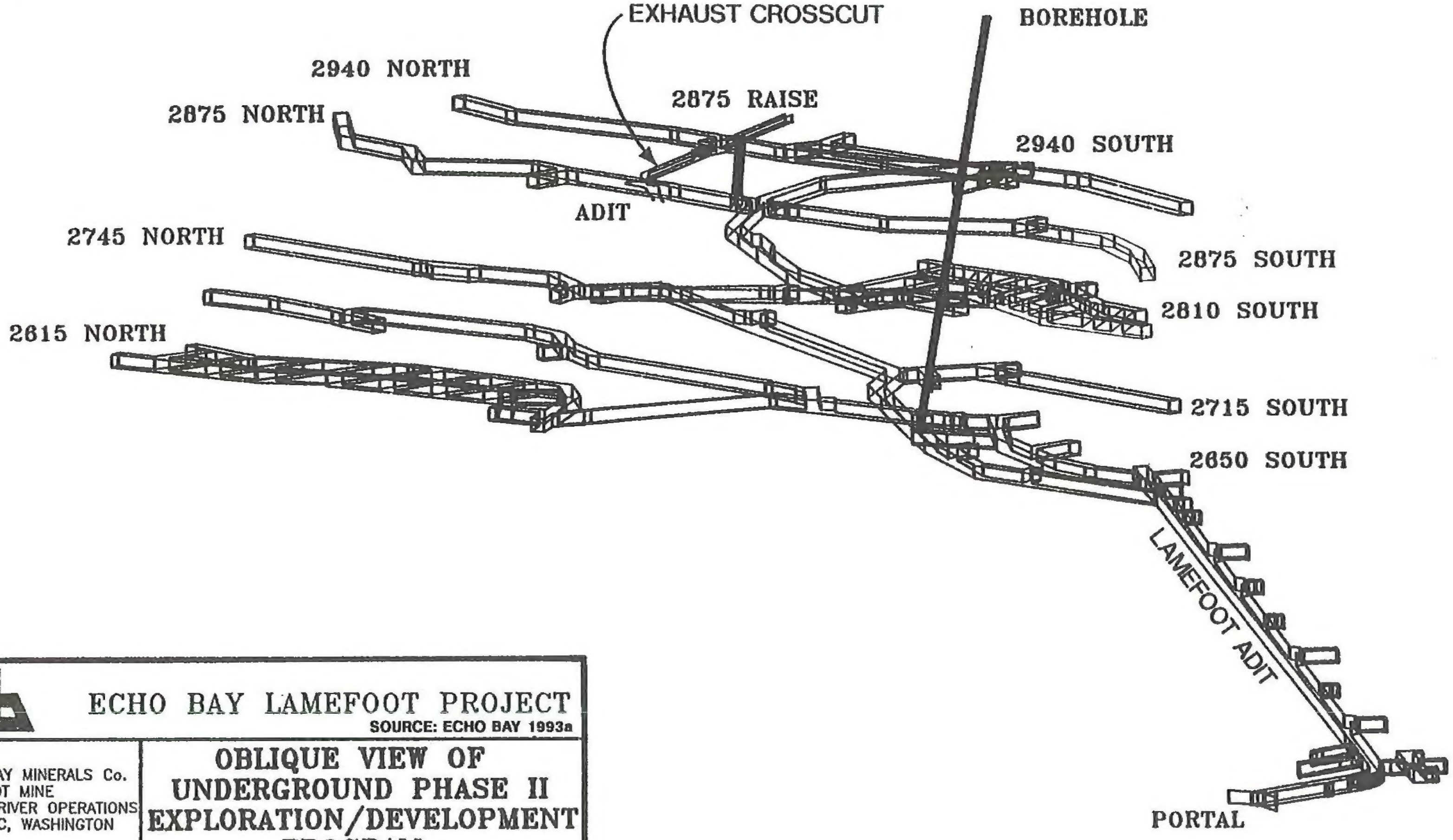
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

OBLIQUE VIEW OF UNDERGROUND PHASE I EXPLORATION/DEVELOPMENT PROGRAM

DATE APRIL 93	SCALE	FIG. NO. 2-15

FILE: OBLPHI.DWG

ELEVATED VIEW LOOKING NORTHEAST



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

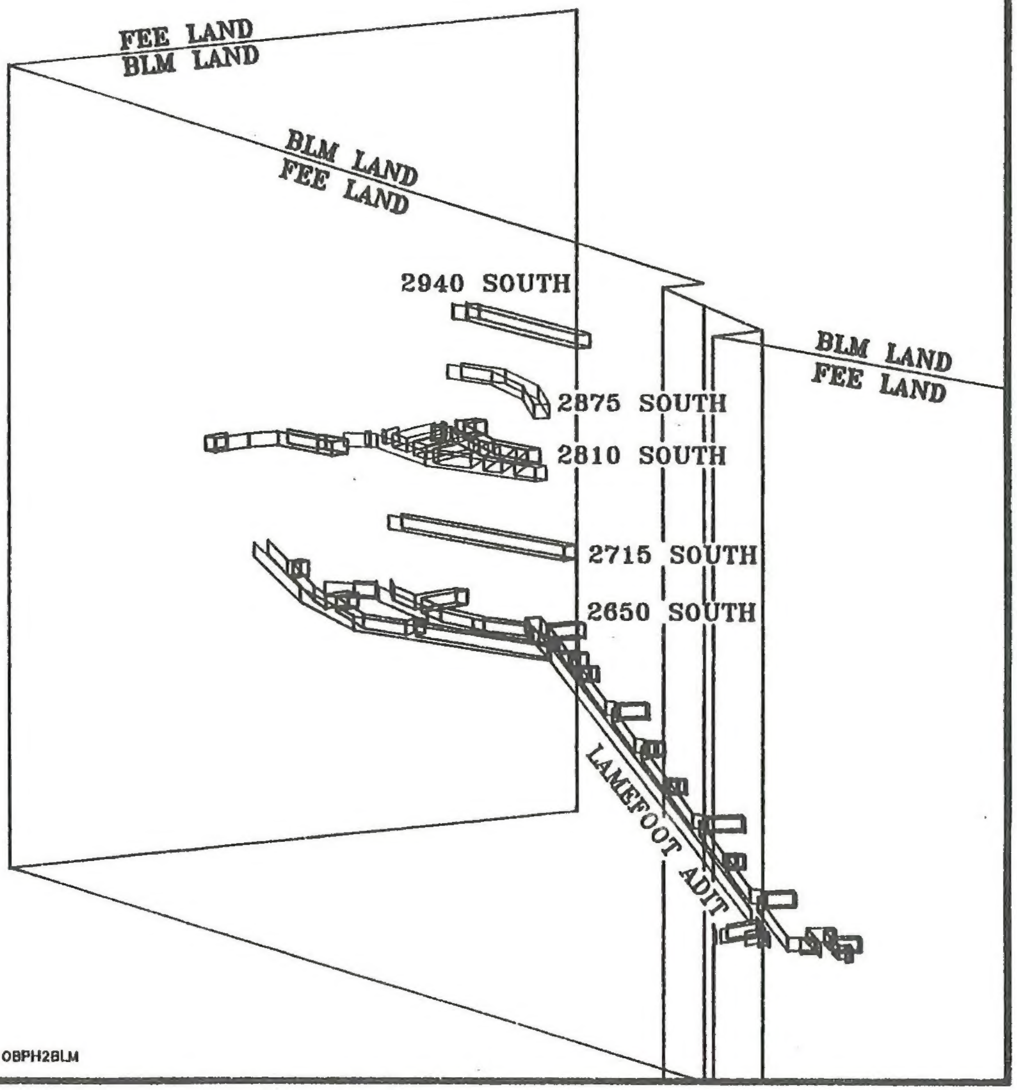
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

OBLIQUE VIEW OF UNDERGROUND PHASE II EXPLORATION/DEVELOPMENT PROGRAM

DATE APRIL 93 | SCALE | FIG. NO. 2-16

FILE: OBLPHII.DWG

ELEVATED VIEW LOOKING NORTHEAST



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

OBLIQUE VIEW OF UNDERGROUND PHASE II PROGRAM ON BLM LAND

DATE APRIL 93 | SCALE | FIG. NO. 2-17

FILE: OBPH2BLM

Diversion ditches have been constructed at the site to control storm water runoff. The site layout showing the previously approved and constructed facilities listed above is presented on Figure 2-6.

2.4 DESCRIPTION OF ALTERNATIVES

2.4.1 Alternative 1 - No Action

The No Action Alternative evaluates the possibility that the mining phase might involve undue and unnecessary degradation that could not be allowed. Note that under the law and regulations, mining activities are not discretionary actions under NEPA. Acceptable impacts include the reasonable and necessary degradation associated with the necessary disturbance required for the extraction of minerals.

Under this alternative, Echo Bay would not receive approval to develop the Lamefoot Mine and would be required to carry out reclamation in accordance with the conditions specified in the approved exploration plan of operations. The opportunity to develop mineral resources, as authorized by law, would be foregone on the public lands. The lack of access would also prevent development of mineral resources on adjoining private lands.

Conditions described in Section 3.0, Affected Environment, would continue to exist, unchanged by activity relating to this mine proposal. The waste rock stockpiles would remain on the surface and would be reclaimed in place.

2.4.2 Alternative 2 - Alternative Drop Pass Access for Backfill

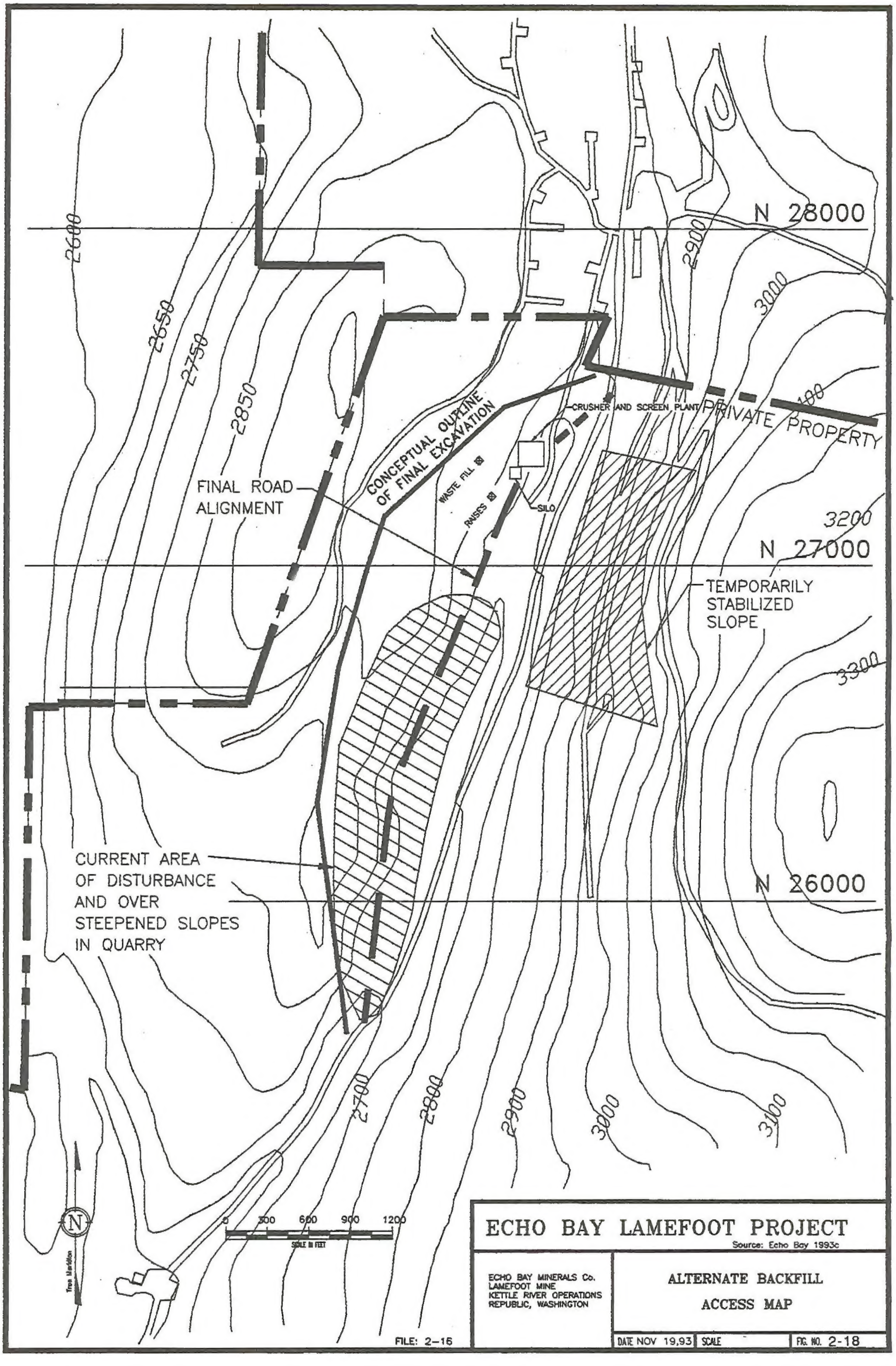
This is the first of two alternatives for introducing backfill materials to the underground workings proposed in this EISS. This alternative includes development of drop passes down to an access ramp from the base of the backfill borrow area, allowing underground access to the workings without crossing the Wolfe Camp Road. This would eliminate the traffic control and safety concerns associated with the meeting of mine traffic and local traffic at the intersection of the portal access road and the county road, as shown on Figure 2-7. In addition, the multi-phase road relocation program would be simplified to a single relocation at closure.

The drop pass backfill access facilities are shown in plan and section on Figures 2-18 and 2-19. A relatively flat bench area would be developed for the surface facilities, using open pit development methods such as drilling and blasting of benches, loading, and truck hauling. The access ramp, sumps, drop passes, and loading chutes would be completed using conventional underground development methods such as drilling, blasting, mucking, and hauling, as described for the Proposed Action.

Surface facilities would include a collared opening for an uncemented backfill drop pass, a collared opening for a cemented backfill pass, a collared opening for an air vent/service raise, a cased drill hole opening for cement access, and a cement silo with baghouse. In addition, a crushing and screening plant may be necessary for backfill sizing if blasting does not produce sufficient fragmentation.

Underground facilities would include a drop pass for uncemented backfill, a drop pass for cemented backfill, loading chutes from each of the passes, a ventilation/service raise, drill hole for cement access, a backfill truck bay/mixing station, and an access ramp to the underground mine workings.

The backfill truck bay would consist of either a circular drive beneath the cemented and uncemented backfill loading chutes or separate back-in drifts. If the circular drive is selected, underground haul traffic would be one-way around the drive, eliminating the need for backing (and resulting noise from backup beepers) of haul trucks.



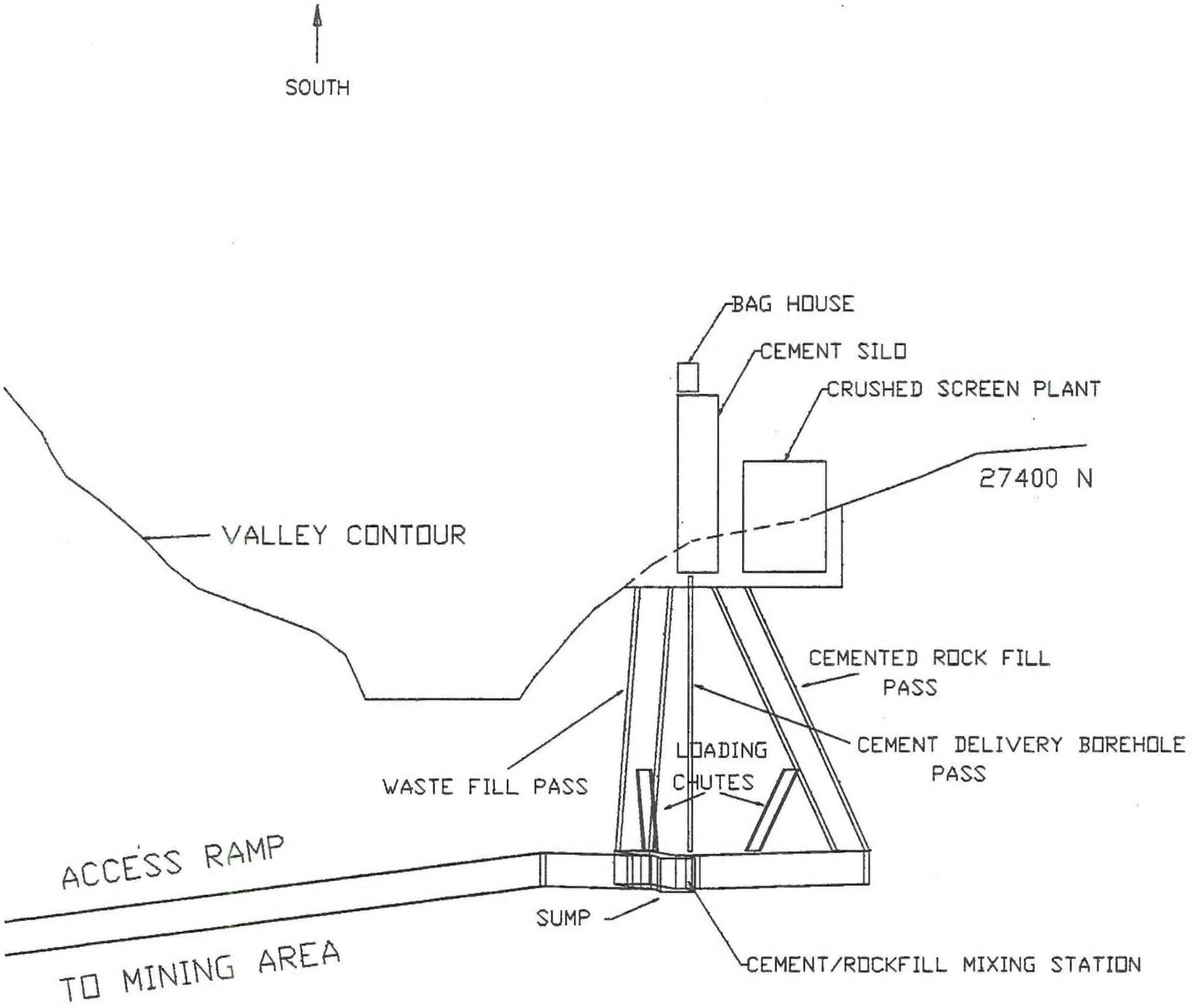
ECHO BAY LAMEFOOT PROJECT

Source: Echo Bay 1993c

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

ALTERNATE BACKFILL
ACCESS MAP

DATE NOV 19,93 | SCALE | FIG. NO. 2-18



ECHO BAY MINERALS CO. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON	Job No. : 23295 Prepared by : S.X.M. Date : 11/19/93	CONCEPTUAL PROPOSED LAMEFOOT ALTERNATIVE WASTE ROCK BACKFILL ASSEMBLY LOOKING SOUTH SOURCE: ECHO BAY, 1993c

FIG. 2-19

Uncemented backfill materials, possibly including oversized fragments from blasting operations, would be dumped into the uncemented backfill drop pass by a front end loader. The drop pass would be filled sufficiently to allow truck loading beneath the gated loading chute.

Cemented backfill materials would be dumped into the cemented backfill drop pass by a front end loader. The drop pass would be filled sufficiently to allow truck loading from a gated loading chute similar to that described above. Cement would be introduced in the appropriate proportions through a valved drill hole terminating at the truck loading/mixing station. Water would be piped to the mixing station from the underground workings. Mixing would occur as the backfill, cement, and water are loaded simultaneously into the waiting haul truck.

Following truck loading, cemented and uncemented backfill materials would be hauled down the access ramp to the underground workings and placed as described in the Proposed Action.

2.4.3 Alternative 3 - Alternative Ore Transportation Route (State Highway 21 and Fish Hatchery Road)

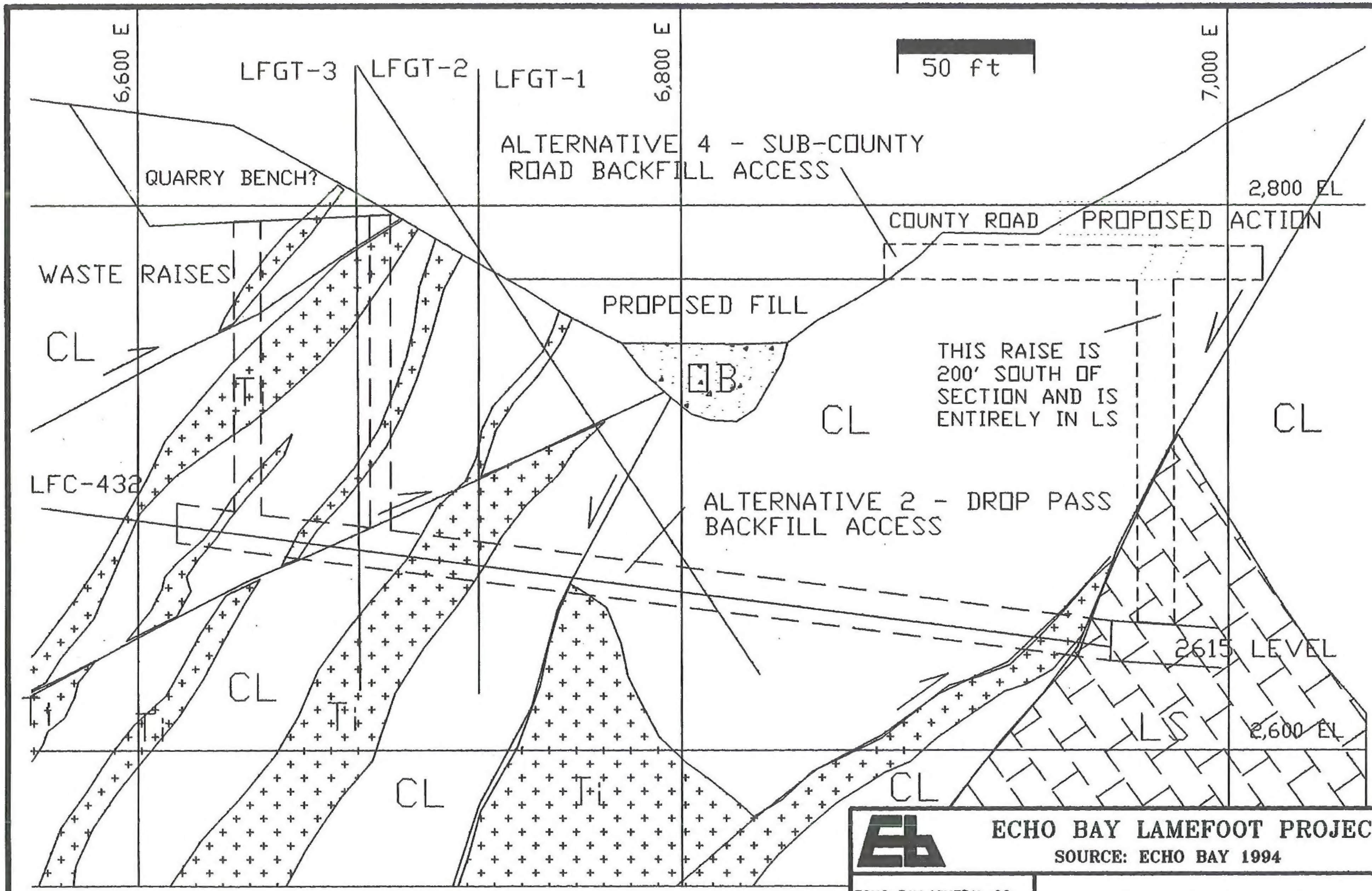
One alternative route is evaluated for hauling ore from the Lamefoot Mine to the Key Mill. The alternative would use State Highway 21 (paved) and existing Fish Hatchery Road, a gravel surface. This option is more attractive from the standpoint of lower capital cost than a newly-constructed dedicated haul road, and presents a shorter haul distance than Old Kettle Falls Road (formerly Cooke Mountain Road). A disadvantage to this alternative is the need to substantially increase road width and sight distance along parts of Fish Hatchery Road to accommodate the increase in traffic. Problems with noise, dust and traffic are concerns which have been expressed by local residents along Fish Hatchery Road in past evaluations of the route. At the request of the County, Fish Hatchery Road has been used in the past as a detour route for mine-related traffic.

2.4.4 Alternative 4 - Alternative Sub-County Road Access for Backfill

This is the second of two alternatives for introducing backfill materials to the underground workings proposed in this EISS. This sub (under) - County Road alternative includes excavation of an adit in the east valley wall of the Wolfe Camp Drainage beneath the existing Wolfe Camp Road. This would eliminate the traffic control and safety concerns associated with the meeting of mine traffic and local traffic at the intersection of the portal access road and the county road as described in the proposed action and shown on Figure 2-7. Traffic on the Wolfe Camp Road is expected to require rerouting for 2 to 4 weeks during construction of the adit and reconstruction of the road. This would also eliminate concerns relating to rock quality and water inflow associated with the deeper, cross valley access ramp described in Alternative 2.

All three backfill access proposals are depicted in relation to the geologic regime on Figure 2-20. The Proposed Action is shown at the same level as the County Road; Alternative 2 as the Drop Pass Backfill Access; and Alternative 4 as the Sub-County Road Backfill Access. Figure 2-21 is a conceptual section showing the cemented rockfill plant in relation to the backfill quarry and the proposed mine workings for Alternative 4. Figure 2-22 shows the portal trace and surface components of the cemented rockfill plant in plan view for Alternative 4.

Wolfe Camp Road traffic would be detoured temporarily along an existing drill road (along the valley bottom) during construction of the adit entry and reconstruction of the road (Figure 2-22). The adit entry would be a 15-foot wide, 18-foot deep open cut through the road covered with a steel and concrete roof, followed by the reconstructed roadway. The mine workings would then be extended to the west to connect with the completed adit entry and portal.



CL = CLASTICS
TI = TERTIARY INTRUSIVES
LS = LIMESTONE
OB = OVERBURDEN

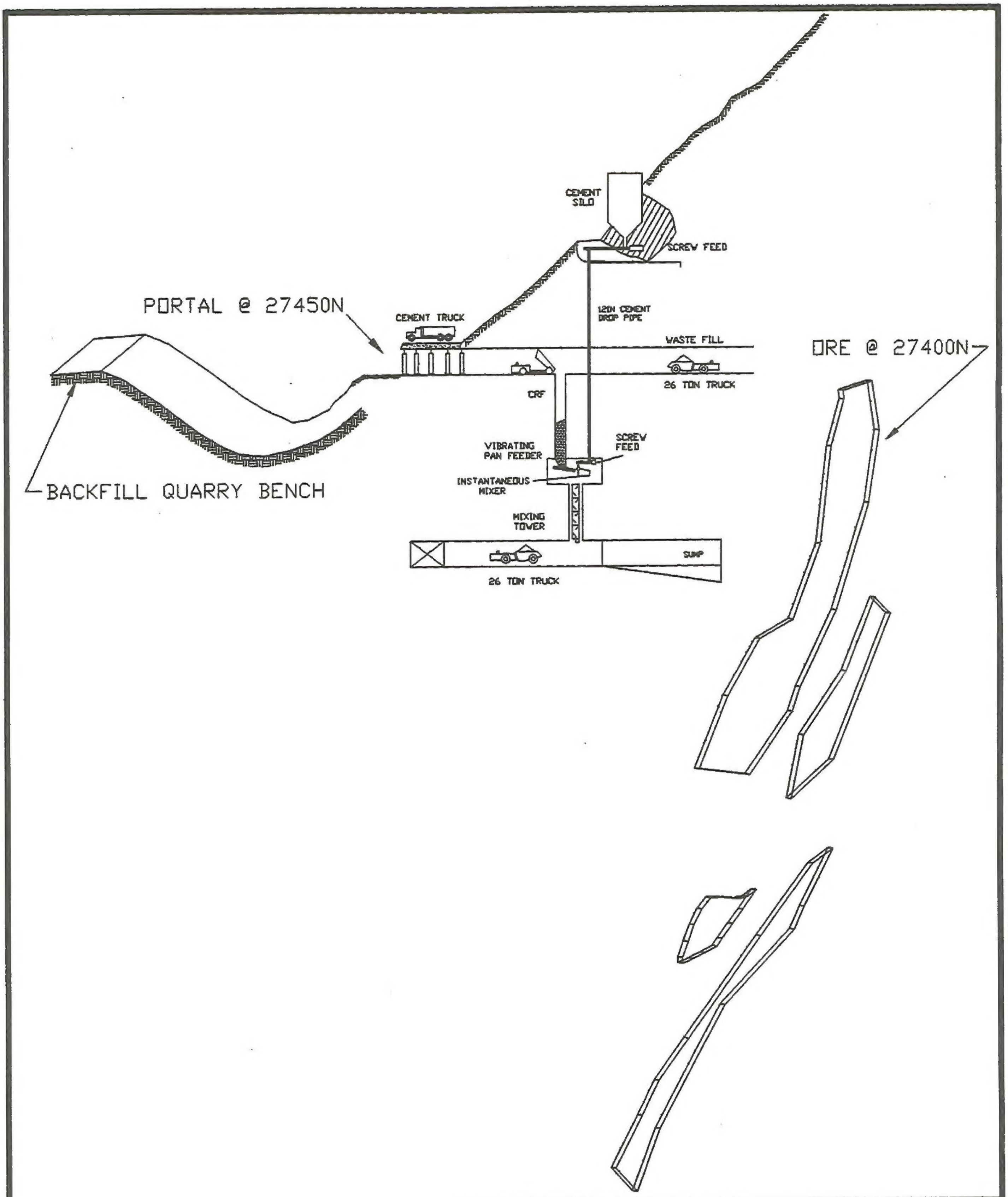
ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAMEFOOT MINE SECTION 27,400 N PROPOSED BACKFILL HAUL

DATE: JUNE 1994 | SCALE: 1" = 50' | FIG. NO. 2-20

LFCRFG



ECHO BAY LAMEFOOT PROJECT

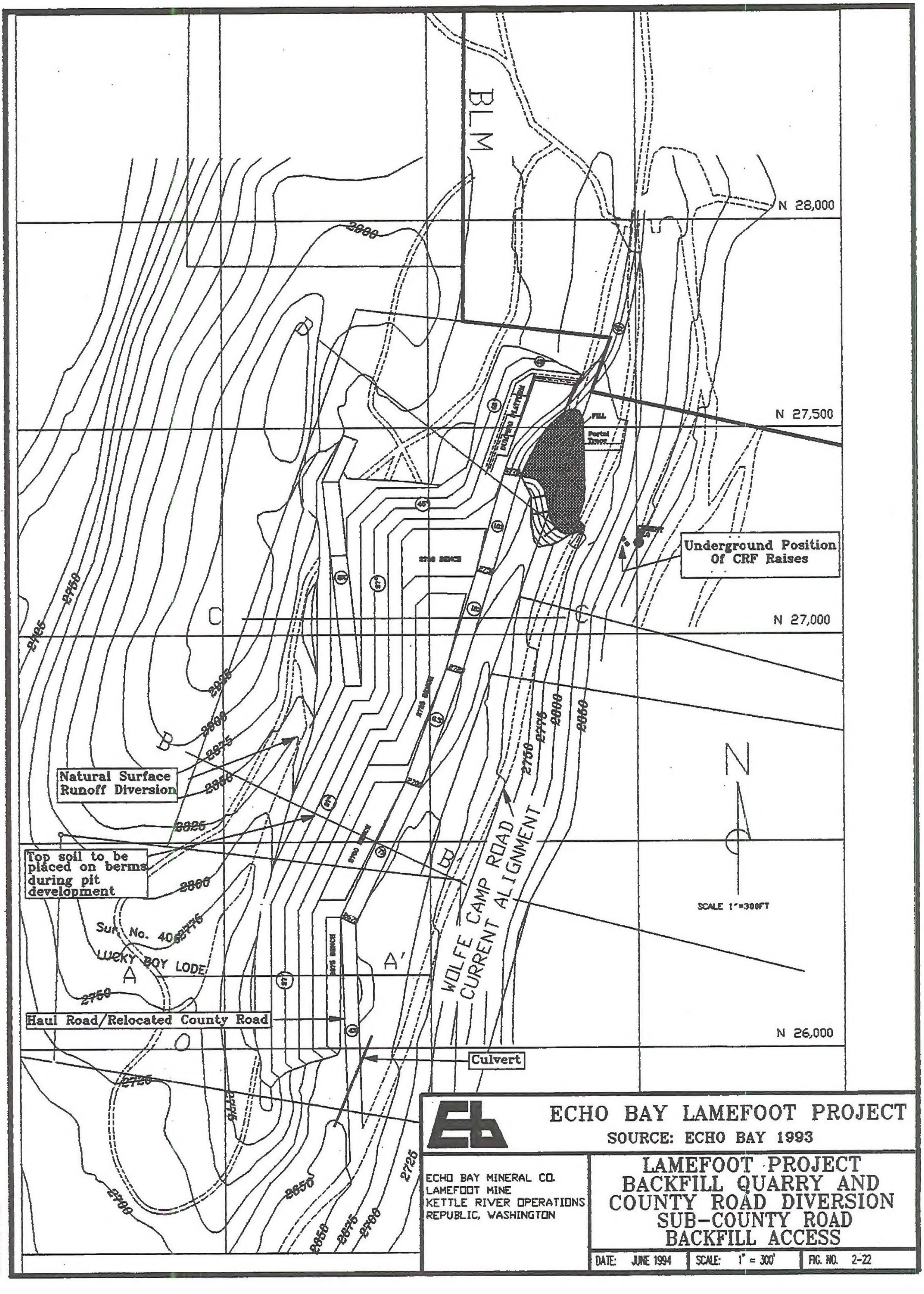
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAMEFOOT PROJECT CEMENTED ROCKFILL PLANT CONCEPTUAL LAYOUT

DATE: JUNE 1994 | SCALE: 1" = 100' | FIG. NO. 2-21

CRFP4B



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAMEFOOT PROJECT
BACKFILL QUARRY AND
COUNTY ROAD DIVERSION
SUB-COUNTY ROAD
BACKFILL ACCESS

DATE: JUNE 1994 | SCALE: 1" = 300' | FIG. NO. 2-22

CURVPIT2

A relatively flat fill area would be developed for access to the portal. The access adit, sumps, drop passes, and loading chutes would be completed using conventional underground development methods such as drilling, blasting, mucking, and hauling, as described for the Proposed Action.

Surface facilities would include the portal and a cement silo with baghouse and would require upgrading an existing road to provide access for haul truck.

Underground facilities would include an upper access ramp for truck hauling uncemented backfill, a drop pass for cemented backfill (Figure 2-21), loading chutes from the pass, a ventilation/service raise, drill hole for cement access, a backfill truck bay/mixing station, and a lower access ramp to the underground mine workings.

The backfill truck bay would consist of either a circular drive beneath the cemented and uncemented backfill loading chutes or separate back-in drifts. If the circular drive is selected, underground haul traffic would be one-way around the drive, eliminating the need for backing (and resulting noise from backup beepers) of haul trucks.

Uncemented backfill materials, possibly including oversized fragments from blasting operations, would be hauled directly to the underground workings from the portal/adit entry.

Cemented backfill materials would be dumped into the cemented backfill drop pass from an underground haul truck. The drop pass would be filled sufficiently to allow truck loading from a gated loading chute similar to that described above. Cement would be introduced in the appropriate proportions through a valved drill hole terminating at the mixing station. Excess mine water would be piped to the mixing station from the underground workings. Mixing would occur in the mixing tower and the backfill, cement, and water mixture is then deposited into the waiting haul truck.

Following truck loading, cemented backfill materials would be hauled down the lower access ramp to the underground workings and placed as described in the Proposed Action.

2.4.5 Alternative 5 - Limited Mine Development - 2,750' Level (Preferred Alternative)

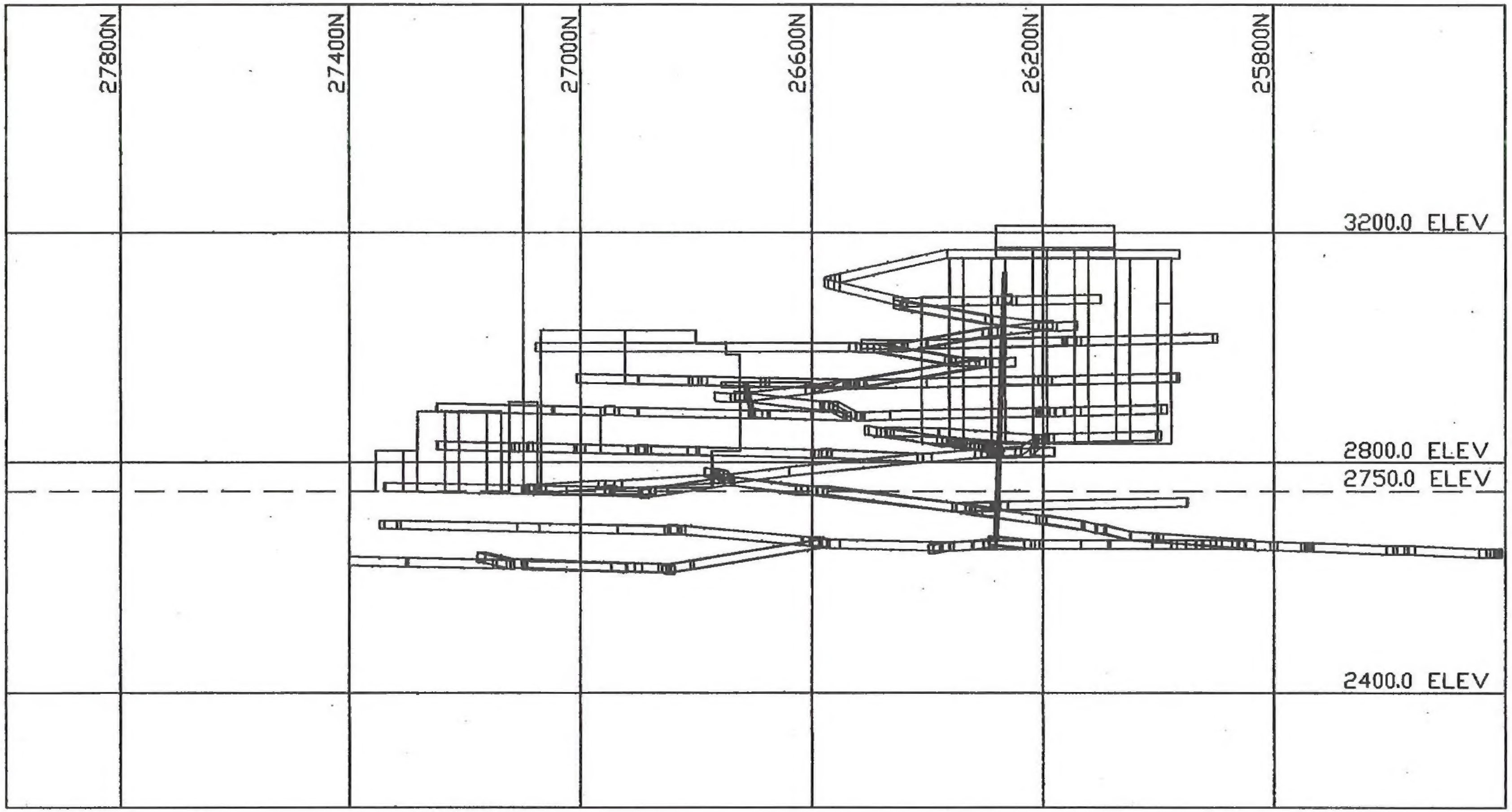
This Limited Mine Development is the same as the Proposed Action except for the following:

Mining would be limited to elevations above the average estimated elevation of the post-closure water table in the mining vicinity of 2750 feet msl. No mining will occur below this elevation. Ore zones that would be mined above this elevation include all of zone 2 and a portion of zones 3 and 4 (see Figure 2-13). Monuments would be established to clearly show the 2750 foot elevation in all access routes and mining zones.

The current kinetic testing program would be completed in early 1995 to further characterize the geochemistry of the ore, waste, and quarry materials. BLM will interpret the post closure concentrations of dissolved constituents in the mine pool using the kinetic test results and other data.

Existing workings below the 2750 foot level and one new portal (see Figures 2-23 and 2-24) could be used to access for hauling of ore, waste rock, and backfill and for drilling activities to collect hydrologic and geochemical data.

Materials with a net neutralization potential (NNP) greater than 20 tons calcium carbonate per 1000 ton of material and a ratio of acid-neutralizing potential (ANP) to acid generating potential (AGP) of greater than three would be considered non-acid-generation material. Only non-acid-generating material from the quarry would be used as backfill within the mine. Cemented backfill, with a high buffering capacity, would be



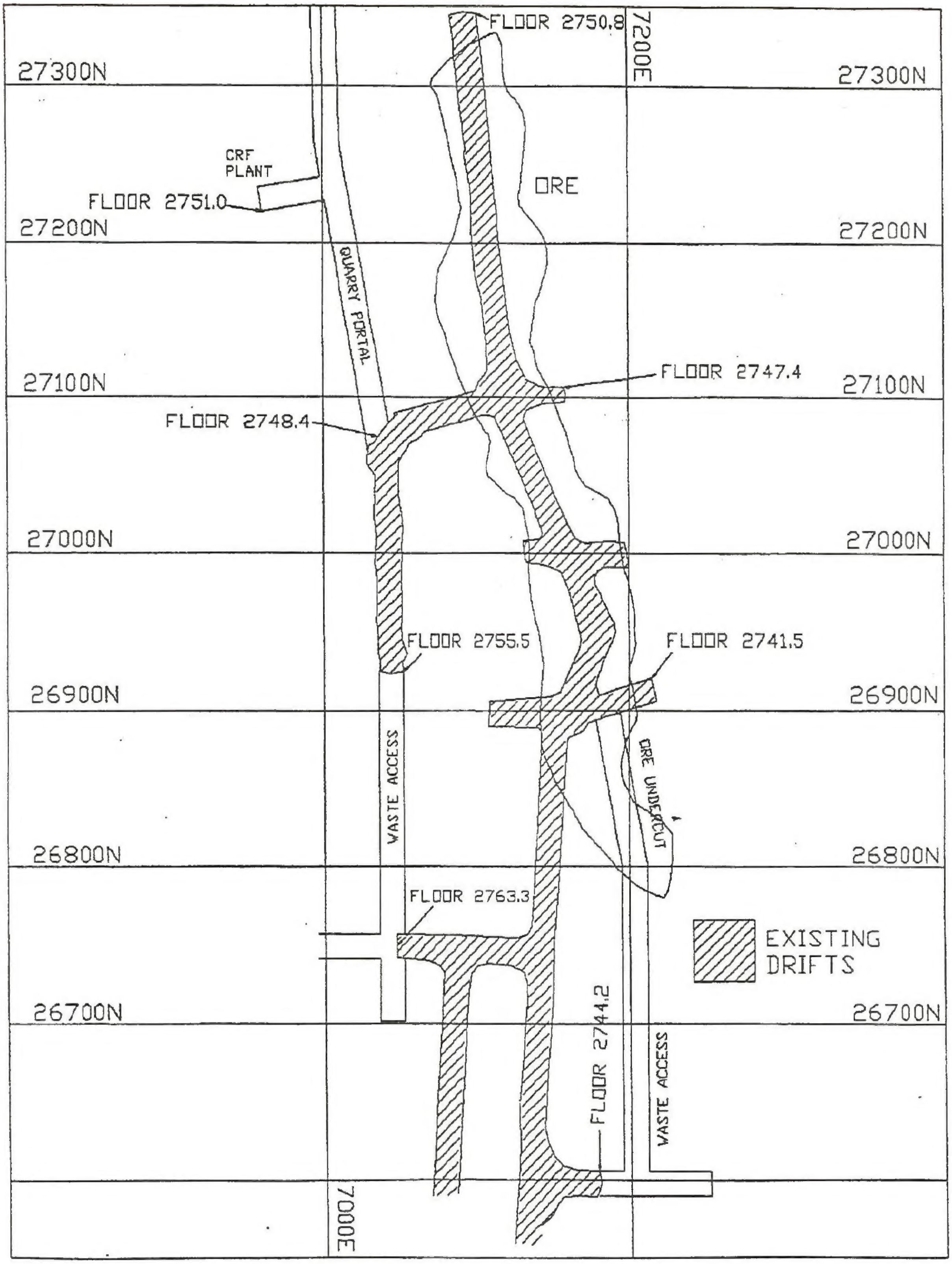
ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1994d

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

EXISTING MINE WORKINGS FOR THE LIMITED MINING ALTERNATIVES

DATE:	SCALE: 1" = 300'	FIG. NO. 2-23

LFSEC1



ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1994d

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

EXISTING WORKINGS AND PLAN FOR NEW WORKINGS
2745 NORTH DRIFT

DATE:
SCALE:
FIG. NO. 2-24

EB

constructed exclusively with non-acid-generating backfill from the quarry. Selective dumping of non-acid-generating backfill material would create an encapsulating system that would typically have a minimum thickness of 20 feet adjacent to exposed rock in the walls, floor, and back of each mining zone.

Any potentially acid-producing materials from the quarry and any potentially acid-producing waste generated in zones two, three and four, along with all existing waste rock stockpile materials, would be allowed only as uncemented backfill following base additions to meet the above-mentioned non-acid-generating criteria. These materials would be dumped in the backfill to form layers alternating between layers of non-acid-generating material from the quarry. All stopes would be completely filled to the back.

Additional characterization of backfill material within the quarry area would be completed prior to quarry construction to better define the location of potentially acid-generating material. This work would include surface sampling and drilling and sampling of drill cores for total sulfur content, acid-basing accounting (ABA) tests, and whole-rock analysis. The backfill quarry for this alternative would disturb approximately 17 acres, which would include the main pit area and additional room for stockpiling, mixing and a possible selective mining area. As with alternative number four, this plan would have a detention berm to prevent surface water runoff from the quarry area.

Analysis results for total sulfur content, net neutralization potential, and the ratio of neutralization potential to acid generating potential, in conjunction with existing data, would be contoured and plotted as an overlay for the backfill quarry. Based on this data, the quarry mining plan would be revised to minimize mining of potentially acid-generating material and to minimize exposures of potentially acid-generating material in the quarry walls.

The revised mining plan would include a mining sequence that identifies the minable quantities of material within each mining block within the quarry.

A groundwater characterization study would be completed by an independent, professional hydrogeologist with expertise in fracture flow analysis. This program would be necessary to assist the BLM in interpreting monitoring results. A workplan that includes time frames would be submitted to the BLM Authorized Officer for review and acceptance. The program would include the following items:

- Additional wells to define the permanent (pre-mining/post-closure) saturated zone (i.e., water table) and water quality throughout the project area. The number, location, and function of each drill hole would be determined following further evaluation of the conceptual groundwater flow model and consultation with BLM.

- Pump tests on some or all of the existing and new wells to determine hydraulic characteristics of the aquifers.

- An interpretive report that refines estimates of the predicted post-closure groundwater level within the mine and adjacent areas based on new data gathered during the required additional hydrogeologic analysis.

- A detailed analysis of the flow system and its role in contributing water inflows to the mine and potential water outflows from the mine, based on existing and new drill hole data. Potential local flow paths and contaminant transport rates would be confirmed, if possible.

- Identification of potential attenuation mechanisms and any additional studies necessary to verify the extent effectiveness of attenuation mechanisms in reducing concentrations of metals or other constituents.

- Recommendations for modification of the existing water monitoring plan based on findings of the study.
- Refinement of the interpretations of background and baseline water quality parameters.

All discharges would have to meet state and federal water quality standards during operations and following closure. This could be accomplished through source control, water treatment, or a combination thereof. If any standards are exceeded during any one-month monitoring period, the operator will consult with the BLM to identify appropriate corrective actions. Where BLM determines that corrective action is necessary, remedial measures approved by BLM will be employed within the following 30 days.

Unnecessary or undue degradation would occur if: a) any standards were exceeded in any three months, which may or may not be sequential within a twelve month period, b) the source of the degradation can be attributed to the operation, and c) the previous corrective measures have been ineffective. If unnecessary or undue degradation occurred and other corrective measures had been ineffective, the operator would submit a plan for water treatment facilities within 30 days.

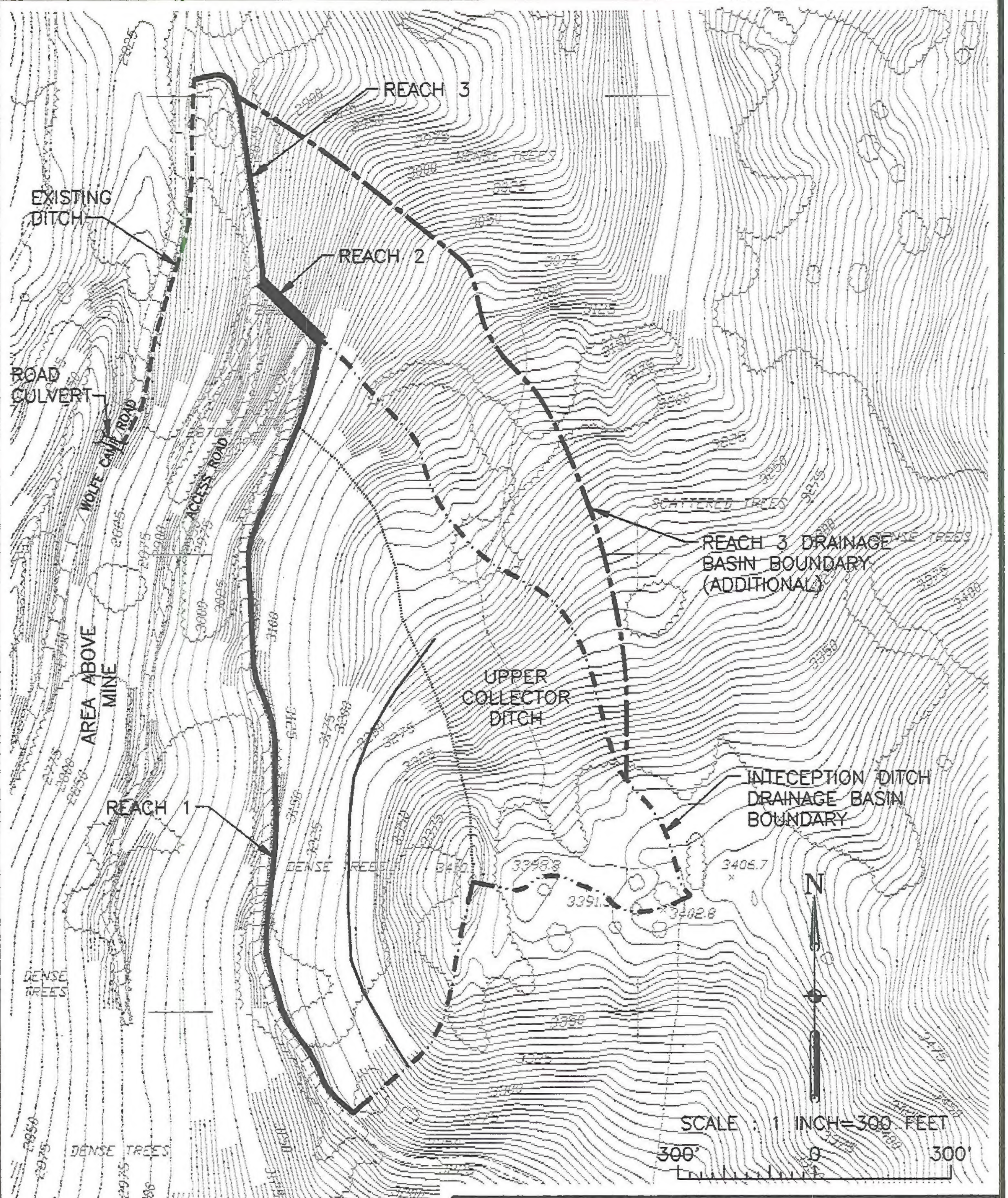
Where unnecessary or undue degradation was caused by excessive nitrate concentrations, the operator would discontinue using ANFO (ammonia-nitrate-fuel oil) explosives immediately following the first month of exceedance. If additional control measures are unable to bring discharge levels within the standards within the next two months, blasting and excavation operations would cease until the treatment facilities are installed and fully functional. Subject to the prior written concurrence of the Authorized Officer, BLM, the operator could identify and initiate alternative measures for rock excavation in lieu of construction of a treatment facility.

Two ditches would be constructed to convey hillslope runoff away from land surfaces directly above the mine workings for the purpose of minimizing infiltration of overland flow and the subsequent inflow of groundwater into mine workings. The locations for these structures are shown in Figure 2-25. Final designs for these structures will be presented to the BLM for approval and will be found in the Plan of Operations for the Lamefoot Mine.

All seeps with peak flows projected to exceed one gallon per minute would be grouted by the operator to zero flow, using the best available technology. Examples of best available technology include using high-penetration grouts (e.g., microfine), high-speed centrifugal mixers, and high-sulfate-resistant cement.

There would be verification by independent, registered professional engineers on the designs, installation, and effectiveness of the grouting program, closure bulkheads, and shaft caps. The operator would submit the names and qualifications of the proposed engineers to BLM, and within five business days, BLM would notify the operator whether the engineers qualify. These engineers would be recognized experts in grouting and closure design, and would review and approve the designs. The engineers would perform periodic quality control/quality assurance inspections, including witnessing installation and preparation of "as-built" engineering drawings. The engineers would submit reports to the BLM Authorized Officer within 30 days after completion of each review and inspection. If the engineers identified variations with the approved designs and installation, BLM would be notified within 24 hours and the construction activities would cease immediately until BLM approval is obtained.

Bulkheads that plug portals and adits constructed during mining would include the following features. They would be designed and constructed in accordance to any applicable codes at the time of construction and would each be designed to account for conditions unique to each site. Each would be constructed with materials that would resist low pH, high sulfates, and other chemically corrosive waters and all existing deleterious conditions. The bulkheads and mine closure program would be designed to eliminate leakage in the proximity of bulkheads and may include grouting as a preventative measure. All designs would be



ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

ROADSIDE INTERCEPTION DITCH PLAN VIEW

DATE: APRIL 1994 SCALE: 1"=300 FIG. NO. 2-25

LFPLN002

prepared by a professional engineer and would be presented to the BLM at least three months before construction. A bulkhead placed in the main portal would include a pipe and valve installation to allow access for sampling and treatment. Most of these features are included in the designs for bulkheads found in Appendix E in Section 9.0, Underground Reclamation in the Plan of Operations for the Lamefoot Mine, but they would be revised to account for the details of this alternative before the closure plan is finalized.

A post-closure monitoring program would be implemented that includes primary, secondary, and tertiary levels of action to address undesirable constituent levels. The measures and type of response actions that would take place are as follows:

> Alert Level Measures - Internal Detection: Two monitoring wells will be placed into the predicted saturated zone of the workings within 30 days after mine closure in locations that would be reviewed and approved by the BLM prior to installation. These would be monitored according to the detailed Hydrologic Monitoring Plan that would be included in the Plan of Operations. Post closure concentrations within the mine pool would be predicted based upon kinetic test results. Any detection of constituents at concentrations greater than the maximum predicted ranges would be reported to the BLM within 24-hours. BLM will then determine whether expanded monitoring frequency, locations, or parameters are needed to evaluate water quality trends. If BLM determines that such expansions are necessary, the operator will comply with BLM's instructions.
>
> Remediation Level Measures - External Detection: In order to verify the effectiveness of source control and containment mechanisms, monitoring of external, wells, springs, and wetlands will occur as previously described in the Hydrologic Monitoring Plan. Within twelve months of completion of the FEISS, the BLM will review the water quality data and determine background levels to set trigger levels for remediation (e.g., 1.5 times greater than background). Trigger levels would be developed in consultation with State agencies, but would not necessarily be the same as water quality permitting standards developed by the State. Any detection of constituents at concentrations greater than (a) trigger levels or (b) more stringent State or Federal standards, will be reported within 24 hours to BLM and to the appropriate State agency. If either of these occur, BLM will require expanded monitoring measures as stated above, plus remediation measures for water quality degradation that threatens to impact beneficial use or natural resources. Remediation could include interception wells, slurry cut-off walls, replacement of water supplies for domestic use, water treatment, and replacement of wetland water supplies.
>
> Extensive remediation - Internal and External Destructions: If monitoring at both internal and external locations indicates that the performance criteria as defined under the Alert Level inside the mine workings and trigger levels outside the mine workings are consistently being exceeded 5 years after bulkhead installation or after post-mining waters reach equilibrium, whichever occurs sooner, then the BLM will require the operator to:
>
> - Take any or all of the measures previously described at the Alert or Remediation levels. BLM will determine which measures are necessary to bring the operation into compliance with the performance criteria.
> - To dewater by pumping solution from the mine portal of dewatering wells.
> - To initiate active water treatment to meet the water quality standards.
> - To enhance source-control measures such as reopening the workings to apply grouting, building cutoff walls, and constructing surface and groundwater diversions upgradient of the mine workings.

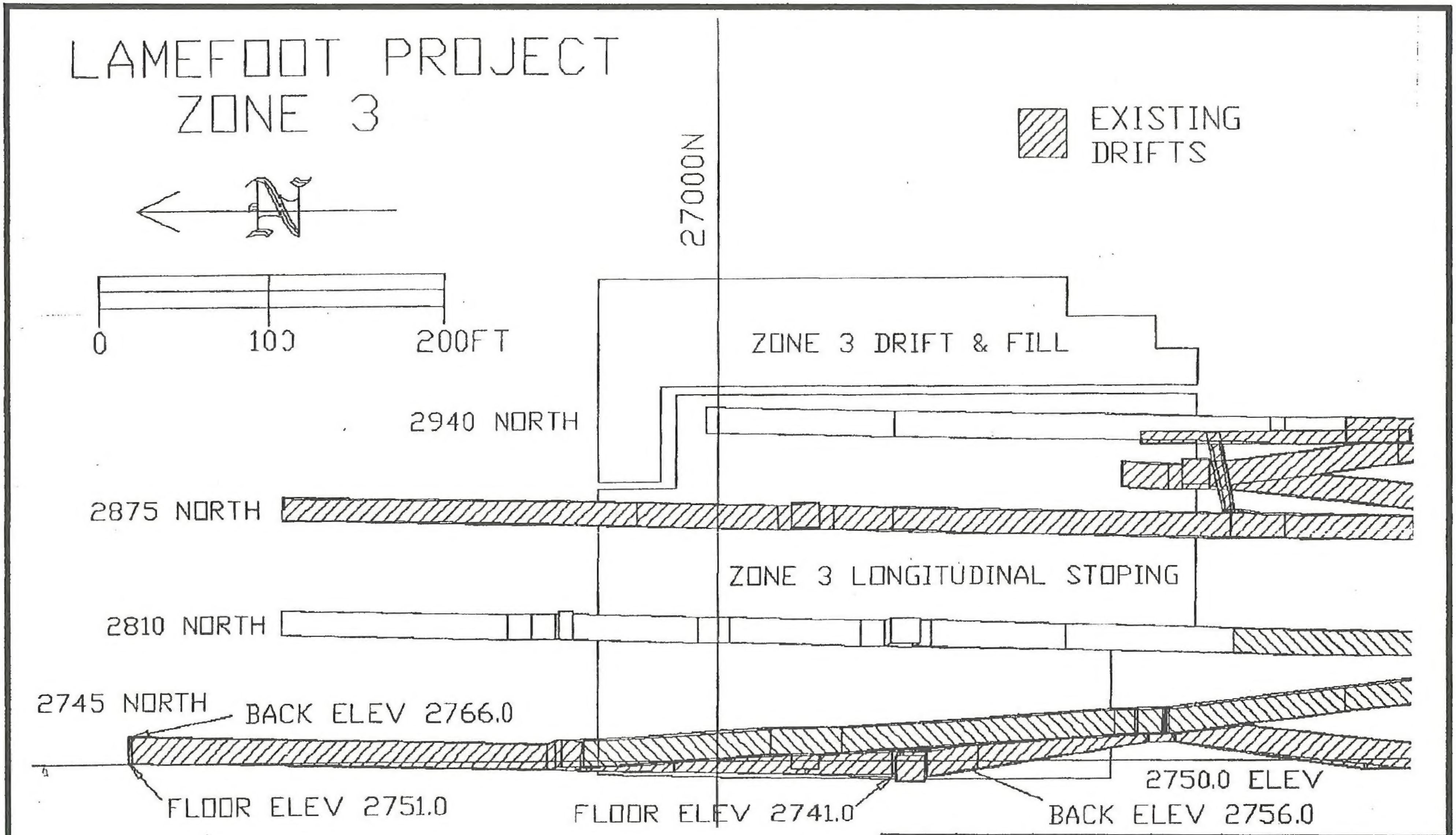
Dewatering and water treatment would continue until source control measures had been demonstrated to be effective in meeting water quality standards.

2.4.6 Alternative 6 - Limited Mining Alternative - 2741' Level

This alternative includes the same mining, backfilling, mitigation and reclamation plans as Alternative 5 with the exception that this alternative incorporates the existing workings at the 2741 foot elevation in Zone 3 (see Figure 2-26).

2.5 COMPARISON OF ALTERNATIVES

Table 2-9 compares and contrasts the various alternatives for each discipline. See Section 4.0 for the detailed impact analysis.



ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1994d

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LONG SECTION 2750'
MINING ZONES

DATE: SCALE: FIG. NO. 2-26

EB1

TABLE 2-9

SUMMARY OF LONG-TERM ENVIRONMENTAL CONSEQUENCES AND COMPARISON OF ALTERNATIVES

Resource	Unit of Measure	Proposed Action	No Action	Alternative Drop Pass Backfill Method	Alternative Ore Transportation Route	Alternative Sub-County Road Backfill Access	Limited Mine[2] Development - 2,750'	Limited Mine[2] Development - 2,741'
Groundwater								
Post Closure Mine Inflow	acre-feet/yr	18	6.25	>18	NC	NC	12.6	12.6
Private Wells Outside Permit Area	NA	NI	NC	NC	NC	NC	NC	NC
Quality	NA	-L	-L	NC	NC	NC	NC	NC
Quantity	NA	-L	NI	-M	NC	NC	NC	NC
Surface Water								
Quality	NA	-L	-L	NC	NC	NC	NC	NC
Quantity	NA	-L	-L	NC	NC	NC	NC	NC
Geochemistry							NC	NC
Water Quality	NA	-L	-L	-M	NC	NC	NC	NC
Geology & Subsidence	NA	-L	NI	-L/M	NI	NC	NC	NC
Aesthetics/Quality of Life	NA	-L/M	-L	NC	NC	NC	NC	NC
Transportation	NA							
State Hwy. 21		-M/H	NI	NC	NC	NC	NC	NC
Wolfe Camp Rd.		-M/H	NI	-L/M	NC	-L/M	NC	NC
Other Roads		-L/M	NI	NC	NC	NC	NC	NC
Noise	-	-L	NI	NC	NC	NC	NC	NC
Soils	-	-L	-L	NC	NC	NC	NC	NC
Air Quality	-	-L	NI	NC	NC	NC	NC	NC
Recreation								

TABLE 2-9
(Continued)

Resource	Unit of Measure	Proposed Action	No Action	Alternative Drop Pass Backfill Method	Alternative Ore Transportation Route	Alternative Sub-County Road Backfill Access	Limited Mine[2] Development - 2,750'	Limited Mine[2] Development - 2,741'
Curlew Lake State Park	NA	-M/H	NI	NC	NC	NC	NC	NC
Other Recreation	NA	-L	NI	NC	NC	NC	NC	NC
Socioeconomics[1]								
Employment								
Direct	jobs	68	-141	NC	NC	NC	NC	NC
Indirect	jobs	102	-211	NC	NC	NC	NC	NC
Total	jobs	170	-352	NC	NC	NC	NC	NC
Earnings								
Direct	$M	17.4	-36.6	NC	NC	NC	5.8	5.8
Indirect	$M	7.2	-14.4	NC	NC	NC	2.4	2.4
Total	$M	24.6	-51.0	NC	NC	NC	8.2	8.2
Tax Revenue		10.8	-10.8	NC	NC	NC	3.6	3.6
Cultural Resources	-	NI	NI	NC	NC	NC	NC	NC
Vegetation*								
Forest (F)	acres	7	7	NC	NC	NC	NC	NC
Forest/Sagebrush (F/SG)	acres	7	7	NC	NC	NC	NC	NC
Sagebrush-Grass (SG)	acres	23	13	NC	NC	NC	NC	NC
Emergent Wetland (PEM)	acres	0	NI	NC	NC	NC	NC	NC
Forested/Shrub-Scrub Wetland (PFO/SS)	acres	0	NI	NC	NC	NC	NC	NC
Forested Wetland (PFO)	acres	0	NI	NC	NC	NC	NC	NC
Quarry	acres	8	8	NC	NC	NC	NC	NC
Total Acres	acres	45	35	NC	NC	NC	NC	NC

TABLE 2-9
(Concluded)

Resource	Unit of Measure	Proposed Action	No Action	Alternative Drop Pass Backfill Method	Alternative Ore Transportation Route	Alternative Sub-County Road Backfill Access	Limited Mine[2] Development - 2,750'	Limited Mine[2] Development - 2,741'
Special Status Species	--	+M	-L	NC	NC	NC	NC	NC
Wildlife								
Mule Deer Winter Range		+M	+H**	NC	NC	NC	NC	NC
Road Kill Hazard		-L	+L	NC	NC	NC	NC	NC
Timber Resources		-L	NI	NC	NC	NC	NC	NC

NI - No Impact
NA - Not Applicable
NC - No Change from proposed action condition
* Vegetation type acreages are approximate due to scale distortion of aerial photo.
** Conditions expected to continue to improve as the plant communities reach climax conditions.
+ Beneficial Impact
- Adverse Impact
L Low
M Moderate
H High

[1] Positive values represent an increase in the number of jobs or earnings due to proposed mining operations, while negative values represent a loss of jobs or earnings due to closure of the Lamefoot exploration program, Key mill, and Echo Bay Kettle River operations office.

[2] Levels of impact would not change relative to the Proposed Action although their duration would be shortened to two years rather than six years under the Proposed Action *except where noted.*

See introduction to Section 4.0 for explanation of impact criteria.

3.0
AFFECTED ENVIRONMENT

3.0
AFFECTED ENVIRONMENT

This section discusses the affected environment (baseline conditions) for each important resource discipline of the proposed Lamefoot project. Since the area in the vicinity of the mine portal was relatively undisturbed prior to 1992, baseline conditions changed incrementally during 1992-1993 in response to Echo Bay's approved exploration activities. Therefore, each affected environment section is generally structured as follows:

1. **The study area** for the particular resource discipline is defined, usually in reference to a map.
2. **General baseline conditions** in the study area, or special terms and background material, may be inserted next.
3. **Baseline conditions prior to 1992 disturbance** are described, especially for the mine portal area, Wolfe Camp drainage, and exploration area.
4. **Baseline conditions 1992-1993**, in response to exploration activities and incremental disturbance, are then defined. Connected action operations (Key Mill and tailings facility) are also outlined, to update the reader on recent activities there.
5. **Special issues for that discipline**, such as reclamation potential or subsidence effects, may be discussed in final sections.

3.1 GROUNDWATER

3.1.1 Study Area

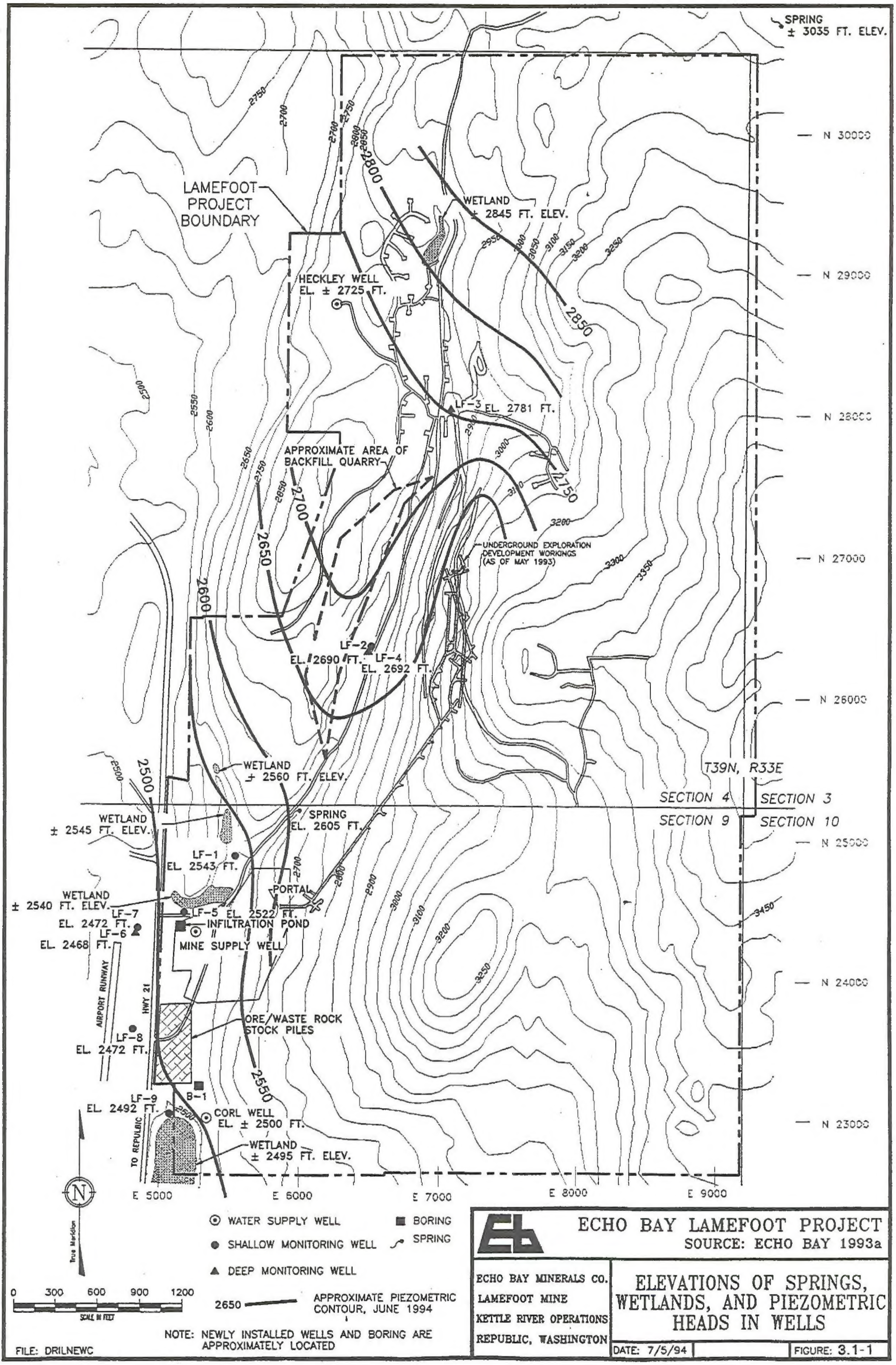
The groundwater study area generally encompasses the Lamefoot project area shown on Figure 1-2, and the area west to Curlew Lake. This area is chosen because effects from the mining operation may influence groundwater in the mine area and downgradient of the mine area as groundwater flows toward the lake. Figure 3.1-1 shows locations of a spring, wells, and wetlands that are part of the groundwater regime in the study area.

3.1.2 Baseline Conditions Prior to 1992

Groundwater baseline conditions prior to mine exploration activities are described in the Environmental Assessment for the Lamefoot Exploration Program (Golder 1992c). Additional groundwater information collected during exploration that is useful to describe groundwater conditions is presented in the updated Plan of Operations (Echo Bay 1994c).

To summarize, the principal aquifers in the regional groundwater system are glacial deposits and alluvial sediments along streams and river valleys. Groundwater in bedrock is expected to occur in relatively small quantities, and typically varies locally depending on the nature and extent of faulting and fracturing. Even if a local fault or fracture zone is quite permeable, the expected quantity of groundwater in storage may be small, unless the zone (a) is interconnected with many fractures, or (b) is in hydraulic connection with a surface water body or saturated porous aquifer, such as alluvium.

The regional groundwater gradient typically mimics topography. In the study area, groundwater flow appears to be to the west/southwest based upon topography and water elevations at wells, springs, and wetlands. The regional gradient is approximately 500 feet/mile based upon measured and estimated pre-mining



ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1993a

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

ELEVATIONS OF SPRINGS, WETLANDS, AND PIEZOMETRIC HEADS IN WELLS

DATE: 7/5/94

FIGURE: 3.1-1

piezometric elevations. Groundwater flows generally toward Curlew Lake, which is approximately one quarter mile west of the project area at an elevation of about 2,340 feet.

Information from two shallow monitoring wells, a nearby domestic well, the mine supply well, exploration borings, and springs, and an evaluation of inflow to the current underground exploration/development workings, provide a basis for a description of groundwater hydrology of the Lamefoot study area. Specific hydrologic data to define baseline conditions are limited in availability and quality. Water quality data for the two monitoring wells in the Wolfe Camp Road drainage are available, as presented in the Environmental Assessment (EA) for the Lamefoot Project Proposed Drilling Exploration Program (Golder 1992c). Background water quality may naturally exceed state groundwater criteria for a number of constituents.

Interpretation of driller's logs pertaining to six wells known to exist in the Lamefoot study area are summarized in Table 3.1-1. Monitoring wells LF-I and LF-2 are completed in alluvium along the floor of the Wolfe Camp drainage.

The mine supply well is drilled through 25 feet of unconsolidated surficial deposits and completed in fractured bedrock at a depth of 265 feet. This well was apparently drilled to intersect the unnamed fault zone which follows the Wolfe Camp drainage. The well is reported to yield over 50 gallons per minute (gpm), and should provide an adequate supply of water because the fault zone is overlain by saturated alluvium and wetlands in the immediate area.

The Heckley well is located on a hill west of the upper Wolfe Camp drainage. It is completed in fractured bedrock at a depth of 360 feet. This location is not on an identified fault and is not overlain by saturated alluvium. The reported yield of the Heckley well is only 0.5 gpm. The Corl well is a six-foot diameter shallow dug well in the surficial deposits south of the waste rock storage area, and is reported to be capped. The Perkl well is a domestic well adjacent to Curlew Lake, and is completed in limestone bedrock to a depth of 120 feet.

A flowing spring is located at an elevation of 2,605 feet along the Wolfe Camp Road. Flow varies seasonally from about 9 gpm in September 1993 to a peak of 60 gpm in early May 1993. It is not known if the source of the spring is alluvium, glacial deposits, or if it is related to bedrock flow systems. The fault zone along the Wolfe Camp drainage coincides with the location of the spring, where this zone of increased permeability may be crossed by another fault or an intrusive rock dike, as suggested by Echo Bay Exploration geologic mapping (Echo Bay 1993e), that diverts groundwater flow along the fault to the surface. The spring discharge flows along the surface and under Wolfe Camp Road to a wetland at the 2,540 foot elevation located east of Highway 21. This wetland is also fed by other wetlands at elevations 2,545 feet and 2,560 feet in a small tributary drainage basin to the west of Wolfe Camp Road. Because of the contribution from this adjacent tributary, the spring is estimated to contribute approximately 50 percent of flow to the lower wetland.

The only other spring known in the vicinity is located outside the study area, about 300 feet northeast of the Lamefoot project boundary in an adjacent drainage basin. This spring appears at an elevation of approximately 3,035 feet on regional topographic maps; however, no other data are available.

3.1.3 Baseline Conditions 1992-1993

Inflow to the mine exploration/development workings, created since 1992, provides additional insight to the occurrence and flow characteristics of groundwater in the bedrock. Flow at discrete points of inflow or seepage are measured or estimated by Echo Bay monthly. The flows are then totaled for an estimate of inflow to the underground workings. Because mine inflow is collected in sumps and is then used during exploration drilling, a precise assessment of natural mine inflow cannot be made. Estimated flows for 1993

TABLE 3.1-1

WATER WELL INFORMATION FOR THE LAMEFOOT STUDY AREA[1]

Well Designation	Use	Depth of Well	Depth of Water	Reported Yield	Aquifer
LF-1	Monitoring	25 ft.	9.7 ft.[2]	NA	Alluvium
LF-2	Monitoring	36 ft.	17.6[2]	NA	Alluvium
Mine Supply Well	Domestic/ Industrial	265 ft.	13 ft.[3]	50 gpm	Bedrock
Heckley	Domestic	360 ft.	125 ft.[3]	0.5 gpm	Bedrock
Corl	Irrigation (capped)	14 ft.	8 ft.[3]	100 gpm	Alluvium
Perkl	Domestic	120 ft.	25 ft.[3]	6 gpm	Bedrock

[1] Based upon data from Washington Department of Ecology well logs (various dates).
[2] Water level measured October 1993.
[3] Water level reported at time of drilling.
NA Data not available.

ranged from 17.5 gpm in April to 7 gpm in June, July, and August. The average mine inflow for the period measured is about 10.4 gpm, or 16.7 acre-feet per year (AFY). Most of the measurable inflows occur at drill holes and at geologic contacts between intrusive rocks and surrounding rock types. Although several faults are intersected by the underground mine workings, these faults appear to be "healed" by mineralization and are not sources of significant inflow. Based upon the low rates of inflow, the Lamefoot is considered to be a relatively dry mine. The cause of this condition appears to be a combined result of the low permeability of the bedrock, the absence of surface water bodies or saturated alluvium above the mine, and the filling of faults and fractures with mineral deposits.

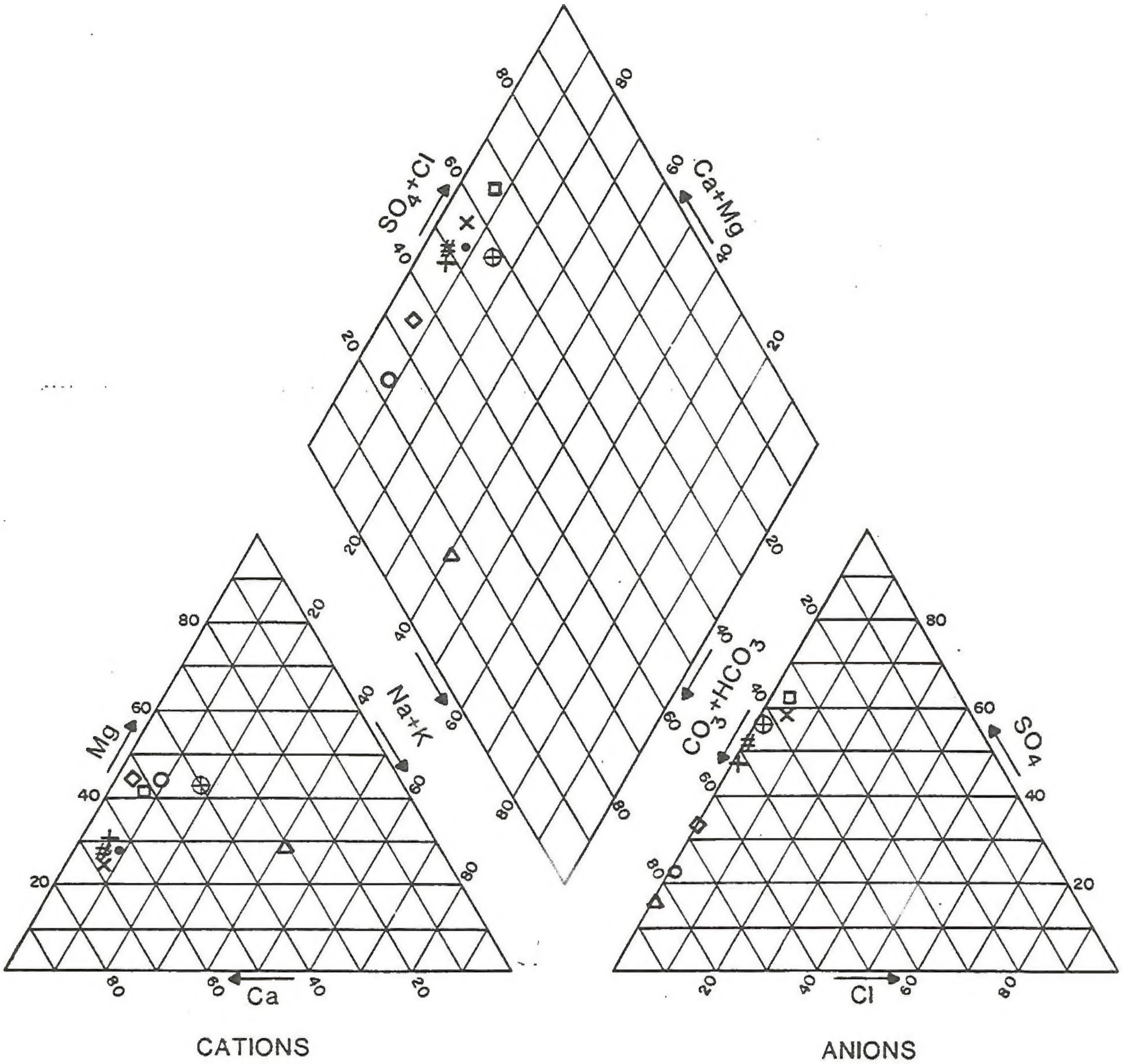
Seasonal variations observed among water levels in wells, spring discharge, and mine inflow all show similar peaks in late April or early May, coincident with snow melt. Water quality of the alluvial wells, bedrock supply well, and mine inflow are characterized as calcium-magnesium-sulfate-bicarbonate type as shown on the trilinear diagram (Figure 3.1-2). The diagram shows that there is some variation between discrete points of mine inflow, but the mixture of these waters, as represented by the mine sump sample, plots very close to the samples from two alluvial wells, the spring, and the bedrock supply well. Groundwater pH is moderately basic, ranging from 7.1 to 8.2.

Groundwater quality monitoring data from wells LF-1 and LF-2 since April 1992 indicate that the background quality of water in the Wolfe Camp alluvium exceeds state groundwater criteria for arsenic, iron, lead, manganese, sulfate, and total dissolved solids. Table 3.1-2 shows background water quality based upon data from wells LF-1 and LF-2. Additional constituents such as selenium may also exceed the state criteria in background; however, only selected parameters are presented on Table 3.1-2. Groundwater discharged from the mine to the infiltration pond also exceeds the Washington state groundwater criteria for the above constituents plus nitrate (State of Washington DOE 1990). It is therefore likely that baseline conditions include some groundwater quality degradation, primarily as a result of nitrate-based explosives used during mine exploration. These water quality data are included in Appendix B-2 and are summarized in an informal spreadsheet in Appendix C-2. The similarities between seasonal flows, water levels, and water quality from the various sources suggests that bedrock and alluvial groundwaters are hydraulically connected and influenced by seasonal infiltration of precipitation.

The discharge from the mine to the infiltration pond is regulated by Washington DOE Permit (No. 803). This permit requires that the effluent be maintained within a pH range between 6.0 and 9.0 units. Other parameters, including specific conductance, total suspended solids, nitrate, copper, zinc, lead, and mercury, are required to be monitored. At present, there are no effluent limitations for the infiltration pond in the permit for parameters other than pH; however, the permit allows DOE to set additional effluent limits if it determines valid cause exists. Summary tables and graphs of the mine infiltration pond data (LF-I) are included in Appendix C-2. These data show that the mine water has contained elevated nitrate concentrations, but that such concentrations have declined since the use of ANFO (ammonium nitrate/fuel oil) explosives have ceased.

Additional data were collected during preparation of this EISS that contribute to the understanding of baseline groundwater conditions at the Lamefoot site. These data were collected during drilling, hydraulic testing, and sampling of monitoring wells installed as part of the Hydrologic Monitoring Program (HMP) described in Section 2.3.5.3 and observations made during drilling of a horizontal core hole to evaluate the Drop Pass Backfill Alternative.

During May and June, 1994, seven new monitoring wells were installed at the Lamefoot site in accordance with the HMP. Data from these wells include hydraulic aquifer test results from the bedrock wells, water level data, and well development records which are included and discussed in the draft "Hydrologic Field Program Report" dated July 11, 1994 (W-C 1994). The first round of water quality samples from the completed monitoring system were collected during the week beginning September 26, 1994.



+ : **SPRING**

• **:BRWELL** (Bedrock water supply well)

□ **:LFM-1** (Mineralized mine inflow)

○ **:LFM-2** (Mineralized mine inflow)

◇ **:LFM-3** (Mineralized mine inflow)

△ **:LFM-4** (Unaltered limestone mine inflow)

⊕ **:LFM-5** (Mine sump)

:LF-1 (Alluvial monitor well)

× **:LF-2** (Alluvial monitor well)

ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

TRILINEAR DIAGRAM SHOWING COMPARISON OF GROUNDWATER CHEMISTRY

FILE: 3-1-4

DATE NOV 19,93 | SCALE | FIG. NO. 3.1-2

TABLE 3.1-2

BACKGROUND WATER QUALITY USING LF-1 AND LF-2 LAMEFOOT PROJECT VICINITY

Constituent	Background Range	n	Average	Washington Groundwater Quality Criteria
Indicator Parameters				
Total Dissolved Solids (TDS) (mg/l)	455 - 1414	48	622.5	500
Arsenic, Dissolved (mg/l)	0.002 - 0.108	48	0.028	
Arsenic, Total (mg/l)	----	--	----	0.05 (μg/l)
Manganese Dissolved (mg/l)	0.001 - 0.676	47	0.034	
Manganese, Total (mg/l)	----	--	----	0.05
Nitrate (mg/l)	0.4 - 1.99	48	0.8	10
Iron, Dissolved (mg/l)	0.009 - 48.4	32	2.34	
Iron, Total (mg/l)	----	--	----	0.3
Sulfate (mg/l)	152 - 335	47	228	250
pH Lab (units)	7.19 - 8.2	48	7.75	6.5-8.5
Secondary Parameters				
Lead, Dissolved (mg/l)	0.001 - 0.1	46	0.032	
Lead, Total (mg/l)	----	--	----	0.05
Zinc, Dissolved (mg/l)	0.001 - 0.257	47	0.020	
Zinc, Total (mg/l)	----	--	----	5

Note: Washington Ground Water Quality Criteria refer to total concentrations.

During the planning stages for the Drop Pass Backfill Access (see Alternative 2, Section 2.4.4), a decision was made to test the rock quality and hydrological nature of the site. During March, 1994, a 500 foot horizontal core hole, LFC-432 (shown on Figure 2-20), was drilled northwesterly from the 2715 West Crosscut. This hole followed the planned trace of the proposed crosscut. Results of the drilling indicated generally fragmented rock quality in clastic rock for the last half of the hole. Initial water discharge from the hole was approximately 6.5 gpm; however, the discharge decreased to about 3.3 gpm after 24 hours. At 10 days the discharge stabilized at about 2 gpm (Echo Bay 1994b). The hole was abandoned and packed with a valved pipe.

These additional data have been reviewed relative to the interpretations and impact assessments represented elsewhere in the EISS, which are based upon data available prior to the recent hydrologic investigations. Based on this review, it is noted that measured hydraulic conductivity values indicate that the estimated value used for impact assessment in this EIS is within the measured range, yet conservatively at the high end of the measured range. There were no fracture zones of extremely high permeability or karst found that would alter the conclusions reached herein. Aquifer geometry and potentiometric levels are also consistent with the interpretations herein.

3.1.4 Mill and Tailing Facility 1989-present

Phase I of the Key Mill Tailing Facility, completed in 1989, consisted of the construction of a mill and tailing pond to process ore from the Overlook and Kettle underground gold mines. Phase 11, an expansion to the Phase I tailing pond, is currently in progress. The initial Phase I cell and the new smaller Phase 11 cell are shown in Figure 2-4. The Phase I cell has a capacity of 2.544 million tons and is lined with a single layer synthetic liner to hold the tailing, which contain trace levels of residual cyanide from the gold leaching process (Golder 1992c). Cyanide is controlled in the Echo Bay process flow by the INCO S02 cyanide destruction system. Cyanide destruction was originally performed by a process involving the addition of sodium metabisulphite to the tailing. In September 1991, this system was replaced with the INCO system, which provides greater capacity for cyanide destruction. (A different system is currently under evaluation by Echo Bay to address lowering costs.) An underdrain system below the liner provides a leak detection system and secondary containment and prevents the buildup of groundwater pressures. Flow from the underdrain is collected on the western (downgradient) side of the pond and pumped back to the pond.

Exploration boreholes were drilled, and piezometers and monitoring wells were installed to evaluate groundwater conditions in the tailing pond area prior to tailing pond construction. Based on this data, groundwater exists in two water-bearing zones. Water in the upper zone appears to sit on top of a relatively impervious, silty layer and exists in minimal quantities (State of Washington DOE 1.988). Water in the lower zone appears to flow on top of the bedrock. The direction of groundwater flow prior to Phase I construction was generally to the south, towards the North Fork of the Sanpoil River. Prior to Phase I construction, the water level data indicated a downward gradient from the upper to the lower water-bearing zones. The current configuration of the groundwater elevation surface cannot be determined, because water levels are not routinely measured in the existing monitoring, wells and because of the number and locations of existing wells.

Since the Phase I construction of the tailing pond, some changes have occurred in the groundwater regime. The existence of a large, lined area in the drainage (the tailing pond) has led to a decrease -M infiltration and less recharge to the groundwater system, while operation of the underdrain system may have contributed to a localized lowering of the water table. This condition also likely led to the drying up of two wells located less than 500 feet downgradient from the tailing embankment. These wells were replaced in 1991 by two additional monitoring wells (TP-1 and TP-2) to monitor the water in the upper water-bearing zone. Washington Department of Ecology (DOE) records indicate that a small spring along the bank of the North Fork near the tailing facility -- used for stock water, irrigation and domestic supply -- also went dry after construction of the tailing pond (State of Washington DOE 1993).

The amended DOE Kettle River Waste Water Discharge Permit defines a monitoring program for the tailing pond, and for groundwater downgradient from the pond. The permit establishes a monthly average limit of 40 ppm WAD (weak acid dissociable) cyanide in the pond. This level is readily achieved by the current INCO SO, cyanide destruction system. Tailing pond waters and monitoring wells are routinely sampled for pH and WAD cyanide 5 times per week. To date, no cyanide has been detected in the monitoring wells. Upon startup of the Key Mill Tailing Facility in December 1989, cyanide was detected in the underdrain system, likely related to small leaks in the liner. Underdrain flow at startup was approximately 3.5 gallons per minute (gpm), and dropped to 0.75 gpm by April 1990 (Echo Bay 1990). The underdrain flow is seasonal and averages 5 gpm based upon Echo Bay monitoring. Monthly average cyanide concentrations in the underdrain sump during this period ranged from 23.9 ppm in February 1990, to 0.3 ppm by June 1990 (Echo Bay 1990). Cyanide levels dropped to non-detectable levels within approximately eight months as the fine-grained tailing on top of the lining appear to have effectively sealed the leaks. Within the past four years of operation, cyanide has been detected only a few times in the underdrain sump. Recent data indicate that cyanide has not been detected in the underdrain for approximately nine months. Based on this information, it appears that the tailing pond liner is effective.

Since 1989, Echo Bay has been pumping groundwater from two wells located in the sand and gravel formation underlying the North Fork for irrigation, domestic and industrial supply, dust control and fire protection. Concerns of local residents and the DOE regarding the effects of this groundwater withdrawal on existing surface and groundwater users prompted the DOE to conduct a groundwater study in 1990. Results of this study indicated that pumping these wells did not have an adverse effect on existing users (State of Washington DOE 1993).

3.2 SURFACE WATER

3.2.1 Study Area

The study area for surface water analysis includes the Lamefoot project area, including the Wolfe Camp Road drainage, Curlew Lake immediately to the west of the Lamefoot project area, and the surface drainages of the Key Mill tailings facility and access road, including Mires Creek, Herron Creek, the Sanpoil River, and Sanpoil Lake.

3.2.2 Baseline Conditions Prior to 1992

3.2.2.1 Regional

Historically, the Overlook Mine and Key Mine areas are drained by streams which flow into the North Fork of the Sanpoil River. The North Fork and the South Fork of the Sanpoil River join to form the main stem of that river. Near the Town of Torboy, a portion of the Sanpoil River flows south to Sanpoil Lake and a portion is diverted north to Curlew Lake. It is not known what percentage of flow goes to each lake. The flow which enters Sanpoil Lake is discharged to the Columbia River some 55 miles to the south. The flow which enters Curlew Lake discharges to the Kettle River some 10 miles to the north of Curlew Lake, which then flows eventually west, to also join the Columbia River. These conditions indicate the complex drainage patterns which exist in the region, caused primarily by glacial landforms.

Historically in the area, water quality and quantity may have been affected by activities in the watershed, such as logging, agriculture, mining, residential development, and road construction. Based on the data available, it is not apparent what effects mining specifically has had on regional water quality.

No data are available to prioritize historical mining and other contributors as to the magnitudes of these effects on water quality in Curlew Lake.

However, as background for this analysis, several reports exist on the water quality of Curlew Lake. One report (Juul and Funk 1988) states that the lake is undergoing cultural eutrophication, and that periodic blue-green algal blooms are caused primarily by (1) occasional high water levels flooding near-shore septic systems, (2) livestock grazing adjacent to inlet streams, (3) past timber harvesting practices, and (4) groundwater sources that have high concentration of phosphorus in some areas. In general, the data suggest that the water quality of the lake is deteriorating due to various historic land disturbances. Parameters of concern include field parameters (temperature, dissolved oxygen, specific conductance), phosphorus, nitrogen, chloride, silica, sulfate, chlorophyll, metals, solids, and light transparency.

Other reports indicate that non-point sources within the Trout Creek and Barret Creek watersheds (tributary to Curlew Lake on the west side) are contributing to water quality degradation in Curlew Lake (Ferry Conservation District 1990; 1991). The Sanpoil River has also been noted as deteriorating with respect to water quality as a result of anthropogenic (human) impacts and land use changes.

3.2.2.2 Study Area

No major streams or tributaries flow through the Lamefoot mine study area; however, an intermittent drainage exists along the Wolfe Camp Road alignment and includes the spring described in Section 3.1. The spring feeds an area which is seasonally wet and boggy, with riparian vegetation. As noted in Section 3.1, this area was described as a wetland in a 1991 field reconnaissance. No outlet from this wetland currently exists. Water which ponds in the wetland area eventually infiltrates into the underlying glacial gravels and does not currently leave the site as surface flow. During extreme events, however, water may overtop the existing Wolfe Camp Road and Highway 21 and flow either west to Curlew Lake or south along Highway 21 to the wetlands area south of the mine portal.

Since no apparent surface flow exists, no information regarding historical water quality in the Wolfe Camp Road drainage is available for review.

3.2.3 Baseline Conditions 1992-1993

3.2.3.1 Regional

The Kettle Mill tailings pond contains materials which are considered to be harmful to the environment and, as such, the pond is operated as a zero discharge facility. The existing tailings impoundments and proposed expansions are designed with diversion ditches sized to convey the 100-year frequency event away from the impoundment (Golder 1992c). The tailings impoundments themselves are designed to contain the 500-year frequency event. The tailings impoundments are also designed to pass and/or store the 100,000-year frequency event without overtopping.

The existing Lamefoot Mine, Kettle River Mine, Overlook Mine, and Key Project Open Pit Mine infiltration ponds, as well as the underdrain of the Key Mill tailings impoundment, are permitted by the State of Washington Department of Ecology under Amended State Waste Water Discharge Permit No. 8033. Under the permit, effluent limitations for pH at the Lamefoot infiltration ponds must be between 6.0 and 9.0. For the Key Mill tailings impoundment, daily average cyanide concentration (reported as weak acid dissociable - WAD) must not exceed 40 mg/l. In addition, frequent monitoring and reporting of certain field parameters is required. In addition to field parameters monitored at the Lamefoot infiltration pond, monitoring and reporting of nitrate and specific metals are required.

Daily water use consumption of the Key Mill and tailings facility is estimated to be 70,000 gallons. Makeup water for operation of the tailings facility is drawn from a well in the Sanpoil River drainage. This water use affects surface flow in the drainage, likely to a low to moderate extent. Table 2-3 presents the project-related water production and use for the Lamefoot project and other Echo Bay operations in the region.

Potential effects of most concern include cyanide releases from the tailings impoundment. The tailings impoundment has been designed with a liner and underdrain system to minimize leakage of process water containing cyanide. Monthly reports from Echo Bay have shown that there has been some liner leakage and detections of WAD cyanide in the underdrain system. This water has been pumped back to the tailings impoundment. No major violations have been noted throughout the operation 1989-1993. WAD cyanide has not been detected in the shallow aquifer monitoring wells, which were installed downgradient of the tailings impoundment.

In the Key Project FEIS (USFS 1992), the only parameters of concern noted were in an upstream tributary to Lambert Creek, east of the Lamefoot project site, which drains to the Kettle River. The monitoring point SW-14 exceeded State of Washington surface water standards for cadmium, copper, lead, and zinc during a December, 1991 sampling event. This monitoring station is characterized in the FEIS as serving to identify naturally occurring variability in the regional surface water quality. Such high background conditions likely exist when flows are low, and are indicative of the ore bodies in the region. Seasonal fluctuations in surface water quality are generally expected in this region, and it is also generally expected that concentrations for most parameters will increase during low flow conditions, and decrease during high flow as a result of dilution. However, high flows may erode additional material and add suspended sediments to surface water runoff.

3.2.3.2 Study Area

Available data for 1993 indicate that the monthly average flowrate for the spring in the Wolfe Camp drainage ranges from 9 to 60 gpm. Flow data for water generated in the Lamefoot mine workings were also available for 1993. The monthly average flowrate in the mine ranges from 7 to 18 gpm; however, this water is generally stored in sumps and recycled for drilling operations in the mine. Any outflow from the mine workings is conveyed to the infiltration pond located at the southeast corner of Wolfe Camp Road and Highway 21. A recent pond percolation field test of the infiltration pond (Hydrometrics, Inc. 1993) indicates that the pond has the capacity to accommodate over 295 gpm of continuous inflow.

The infiltration pond associated with the existing Lamefoot mine continues to operate under Amended State Waste Water Discharge Permit No. 8033. To recall, the effluent limitation of pH must be between 6.0-9.0, according to the permit. Monitoring and reporting of pond water quality parameters are also required by the permit. Parameters monitored include pH, specific conductivity, total suspended solids, nitrates, copper, zinc, lead, and mercury.

3.2.4 Hydrologic Analysis

A hydrologic analysis of the Wolfe Camp Road drainage was performed to estimate surface water runoff generated within the watershed for various frequency events. The 2-year, 25-year, and 100-year frequency 24-hour precipitation depths for the area were estimated from the National Weather Service's Technical Paper No. 40 (Hershfield 1961) to be 1.5 inches, 2.5 inches, and 3.0 inches, respectively.

Based on soils and vegetation data for the watershed, a Soil Conservation Service (SCS) curve number (CN) of 69 was estimated for the watershed (Ponce 1986). The time of concentration (defined as the time for water to travel from the most hydraulically remote point in the watershed to the outlet) was estimated to be approximately 0.8 hours. The Wolfe Camp Road drainage area was estimated to be approximately 450 acres.

The U.S. Army Corps of Engineers HEC-1 computer model was used to estimate the peak runoff rates and volumes of the Wolfe Camp Road drainage. Based on the analysis, the peak runoff rates for the 25-year and 100-year precipitation frequency events were estimated to be 60 and 100 cubic feet per second (cfs), respectively. Runoff generated from the 2-year frequency precipitation event is estimated to be negligible, due to storage and infiltration of runoff in wetlands areas. The estimated runoff volume from the 2-year, 25-year, and 100-year precipitation frequency events is estimated to be 2.6 acre-feet, 16 acre-feet, and 25 acre-feet, respectively. The wetlands area at the northeast corner of the Wolfe Camp Road and Highway 21 intersection has an estimated storage capacity of approximately 1.9 acre-feet. Hydrologic calculations are included in the project files.

Based on soils and vegetation information for the Wolfe Camp Road drainage watershed, it is estimated that surface water runoff does not occur for precipitation events less than approximately one inch. Under extreme rainfall events, however, surface water runoff will be generated in the watershed. Surface waters will pond on wetland areas until overtopping of roads, high ground, and similar areas occurs.

3.3 GEOCHEMISTRY

3.3.1 Study Area

The study area pertinent to geochemistry issues is shown as the Lamefoot Project area and Key Mill/tailings areas on Figure 1-2.

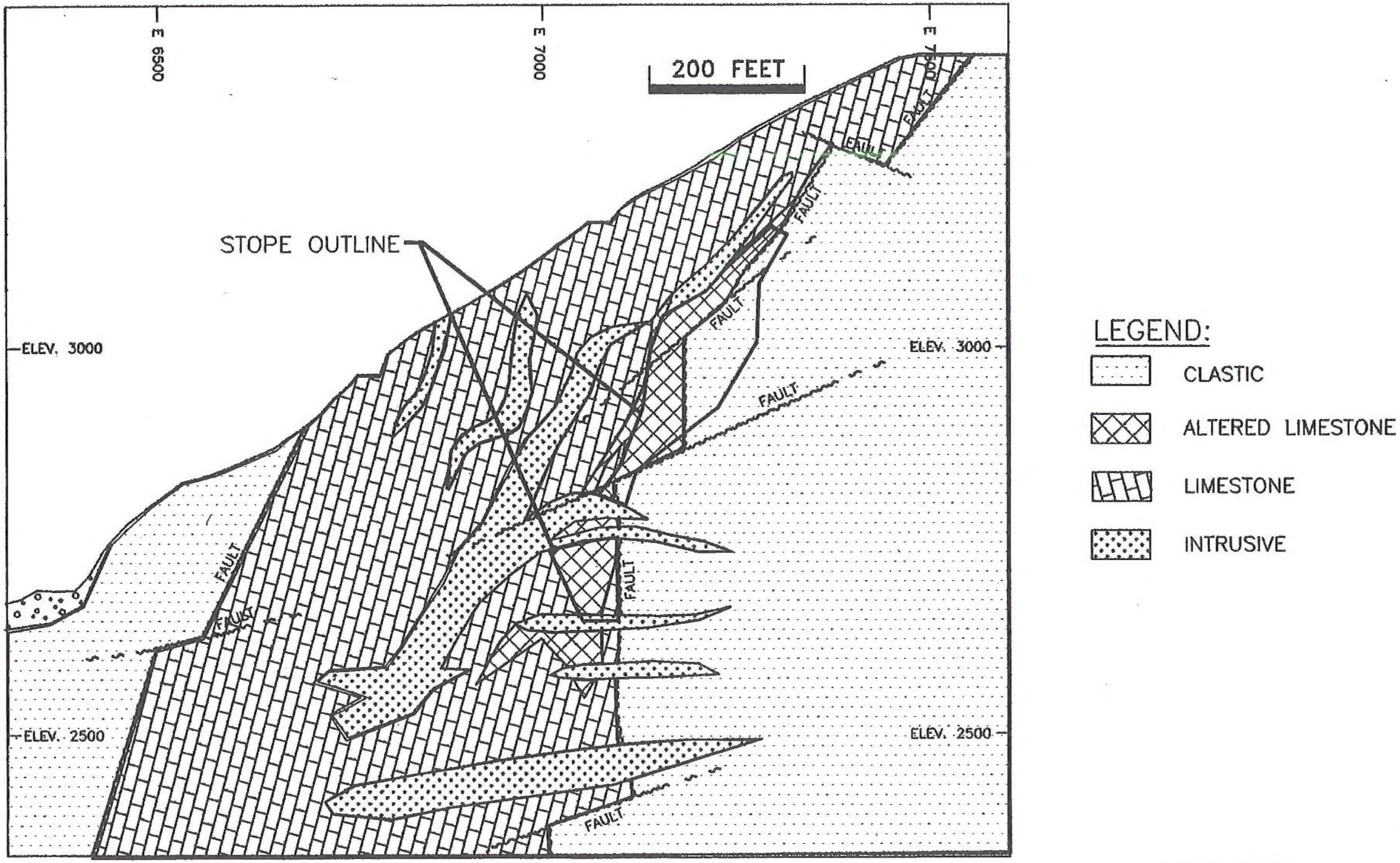
3.3.2 Baseline Conditions Prior to 1992

Geochemical baseline conditions — those prior to mine exploration activities — are described in Golder (1992c). In general, the geologic materials in the mine area (soils and bedrock units) were undisturbed by human activity, with the exception of a few exploration drill holes and the pre-existing Wolfe Camp Road Quarry. There is no obvious evidence of water quality degradation due to geochemical processes during this period. In addition, all known available and reasonable technologies have been incorporated into the design to mitigate any water quality degradation.

In the mill and tailings area, the mill facilities and tailings impoundment had been constructed, and a few monitoring wells and piezometers had been installed. Geochemically speaking, such activities had exposed some alluvium to weathering, and some minor, temporary leaks of tailings waters into the tailings underdrain had been detected during startup. These leaks were evidenced by elevated pH (about 9.0 to 10.0) and detectable cyanide concentrations (from 0.3 mg/L to 23.9 mg/L; Echo Bay, various dates). Within approximately eight months, cyanide concentrations had declined to non-detectable levels, and leaks in the underdrain have been few and of low concentrations. None of the monitoring wells has shown evidence of elevated chemical constituent concentrations. Lastly, several exposed ore stockpiles were constructed in the mill area. No visual evidence (such as accumulation of salts or staining) of water quality degradation from these stockpiles has been detected.

The Lamefoot Mine will be developed in weakly metamorphosed sedimentary and volcanic rocks (see Section 3.4). The dominant lithologies are metamorphosed limestones and greywackes of Permian age (Golder 1992c). Figures 3.3-1, 3.3-2, and 3.3-2a show representative geologic cross-sections constructed from exploration bore hole data which also illustrate the distribution of the waste rock lithologies (Golder 1993; see Appendix B-1). The dominant lithologies are described as follows:

> **Limestone:** Light to dark gray, massive with no apparent bedding, sandy to micritic in texture, locally sparitic, weak to moderate argillization, sulfides consist mainly of pyrite, sulfide occurrence is limited to veins and veinlets. Sulfide habit is generally amorphous to euhedral, and visual quantities are estimated to range from trace to five percent.
>
> **Low Grade Ore:** Dark greenish gray and brownish gray mottled altered limestone, sandy to micritic in texture, occasionally dolomitic, mineralized zones contain quartz veins and/or pervasive silicification with significant sulfides, magnetite, and/or hematite. Sulfide minerals consist primarily



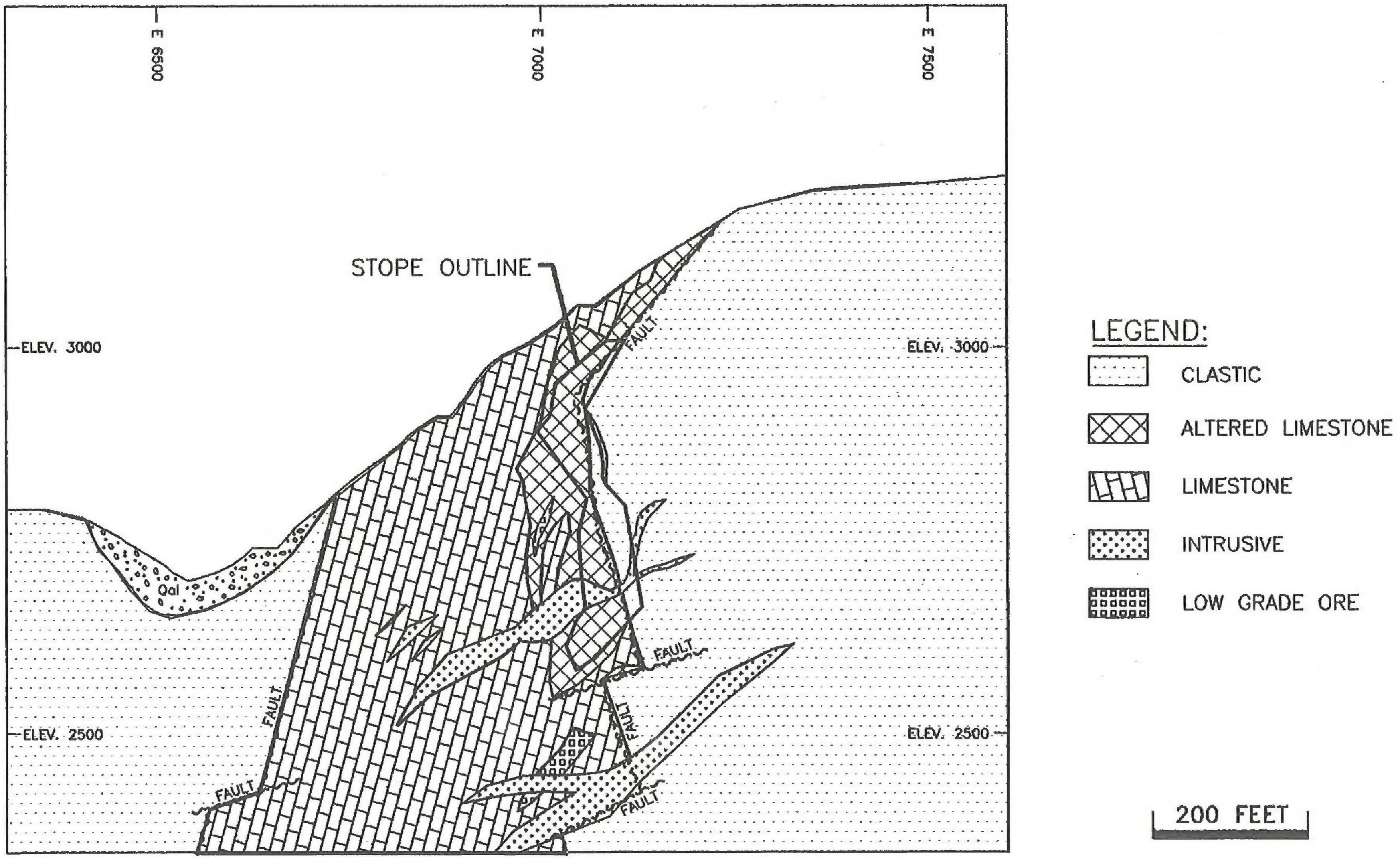
SECTION 26,100 NORTH
LOOKING NORTH

200 FEET

ADAPTED FROM GOLDER 1993

CLIENT/PROJECT	ECHO BAY MINERALS Co. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON		TITLE GEOLOGIC CROSS SECTION SECTION 26,100 NORTH

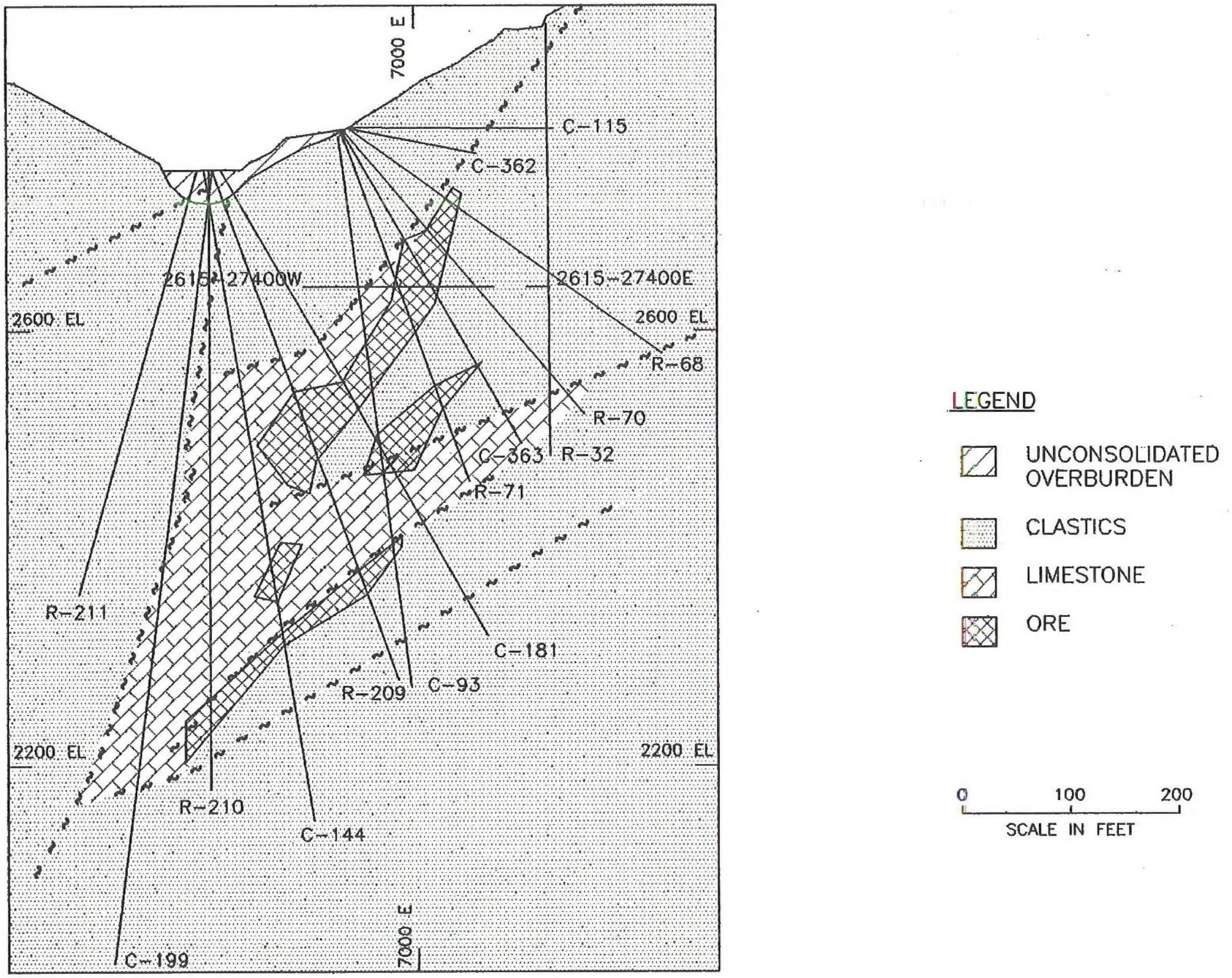
DRAWN	CHECKED J.C.	REVIEWED L.E.C.	DATE NOV 1993	SCALE AS SHOWN	FILE NO.	JOB NO. 933-2614	DWG NO./REV.NO. 261AGP	FIGURE 3.3-1



SECTION 26,900 NORTH
LOOKING NORTH

ADAPTED FROM GOLDER 1993

CLIENT/PROJECT	ECHO BAY MINERALS Co. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON				TITLE	GEOLOGIC CROSS SECTION SECTION 26,900 NORTH	
DRAWN	CHECKED J.C.	REVIEWED L.E.C.	DATE NOV 1993	SCALE AS SHOWN	FILE NO.	JOB NO. 933–2614	DWG NO./REV.NO. 269AGP	FIGURE 3.3–2



CLIENT/PROJECT	ECHO BAY MINERALS Co. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON				TITLE	GEOLOGIC CROSS SECTION 27,400 NORTH LAMEFOOT PROJECT SOURCE: ECHO BAY 1994	
DRAWN	CHECKED	REVIEWED	DATE FEBRUARY,1994	SCALE AS SHOWN	FILE NO.	JOB NO. 23295	DWG NO./REV.NO.	FIGURE: 3.3-2A

GCS

of pyrite which ranges in occurrence from massive to disseminated. Cumulative percentages of sulfide, magnetite, and/or hematite generally exceed 5 percent and in some areas can exceed 50 percent.

Clastic: Siliciclastic rock ranging from siltstone to sharpstone conglomerate, containing both greenstone and localized carbonate intervals. Sulfides consist primarily of pyrite and range from less than one percent to 10 percent depending on proximity to mineralization. Pyrite occurs mainly in veinlets and fractures with both calcite and quartz.

Intrusive: Porphyritic rhyodacite with biotite or hornblende. Alteration ranges from propylitic to argillitic with calcite and chlorite as common alteration products. Sulfide percentages range from zero to 0.1 percent and typically are disseminated throughout the groundmass.

Figure 3.3-3 shows the estimated rock type percentages that will be used to backfill the Lamefoot mine. The backfill material will come from two sources; the Wolfe camp quarry and from mine development waste rock. Waste rock will make up approximately 15.4 percent of the material used to backfill the underground workings. The dominant rock types of the waste rock are limestone (about 64 percent) and clastics (about 21 percent). Approximately 83.6 percent of the backfill will be materials from the Wolfe Camp quarry. These quarry backfill materials are primarily composed of clastics with minor amounts of intrusive rock. Clastic rocks are the dominant type of backfill material, accounting for about 88 percent of backfill, and are composed of siliciclastic siltstones, with variable amounts of sulfide and carbonate mineralization. Portions of the clastic rocks exhibit significant degrees of oxidation, which generally decrease with depth. Sulfide occurrence is primarily as fine grained disseminations within the matrix and quartz veins. The intrusive rocks are fine grained, with phenocrysts of biotite and feldspar; trace calcite and pyrite occur within veinlets and the groundmass.

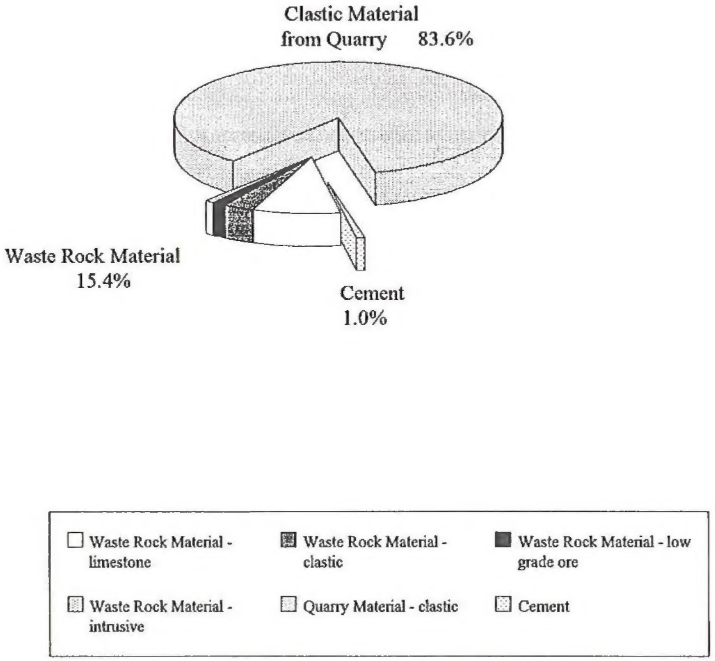
Hydrogeologic Relationships

Groundwater within the deeper bedrock (i.e., at the depths of the current Lamefoot exploration site) occurs as fracture flow (Echo Bay 1993a). Inflows to the mine workings are low, between 10 to 26 gpm (this highest value experienced during a high flow period, May 1994, before grouting) from both fracture and exploration borehole inflows (Echo Bay 1993a). Although only small amounts of groundwater have been encountered in the site bedrock, there is the potential for greater flows where large, interconnected, open fractures occur and as the mine workings extend into the saturated zone (see Section 3.1).

Relatively few pre-mining groundwater analyses are available for the mine site area. Water quality of the fractured bedrock and surface glacial/alluvial deposits was evaluated using mine inflow samples collected during the underground evaluation, from monitoring wells LF-1 and LF-2, from the bedrock well supplying the Lamefoot facilities, and from the spring. These features are also discussed in Section 3.1.3, with the water quality analyses for wells LF-1 and LF-2 shown in Appendix B-2. Analyses of the mine inflow samples, the bedrock supply well, the spring, and a mine sump are summarized in Table 3.3-1, originally presented in the Plan of Operations (Echo Bay 1993a). Most of the samples for these wells, the spring, and mine inflow sources were collected during 1992 and 1993, and thus do not represent water quality from absolutely pre-mining conditions (see Section 3.3.3). The data indicate the presence of moderately alkaline waters (pH 7.8 to 8.1) with specific conductance ranging from about 600 to 2,640 μmhos and alkalinities from about 250 to 380 mg/l. Thus, there is no direct evidence of existing acid generation. Most draining underground boreholes show some iron staining, indicating that sulfides are being oxidized, but no lowering of pH has been noted. No staining was observed on wet massive mineralized limestones (Echo Bay 1993a). The alkalinity data suggest these waters possess significant buffering capacity.

Additional water quality samples were collected in September 1994. These data are discussed in Appendix C-3.

Backfill Source	Rock type	tons x 1000	Percent of Total Backfill Material
Waste Rock Material	Limestone	160	9.8
	Clastic	53	3.3
	Low grade ore	22	1.4
	Intrusive	15	0.9
	Waste Rock Subtotal	**250**	**15.4**
Quarry Material	Clastic	1363	83.6
Added Cement	Cement	17	1
	Total Backfill Material	**1630**	**100**



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

ESTIMATED BACKFILL ROCK TYPE PERCENTAGES LAMEFOOT PROJECT

DATE: JUNE 1994 | SCALE: | FIG. NO. 3.3-3

TABLE 3.3-1

WATER QUALITY ANALYTICAL RESULTS OF SAMPLES COLLECTED DURING MARCH 1993 UNDERGROUND HYDROGEOLOGIC SURVEY

	Samples						
Analyte	LFM-1	LFM-2	LFM-3	LFM-4	LFM-5	Spring	BRWELL
Alkalinity	351	384	334	320	278	279	267
Bicarbonate	351	384	334	320	278	279	267
Aluminum-D	<.01	<.01	<.01	<.01	.43	<.01	<.01
Arsenic-D	<.04	<.04	<.04	<.04	<.04	<.04	<.04
Boron-D	.02	<.01	.01	.06	.04	<.01	<.01
Cadmium-D	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Calcium-D	246	97.3	104	45.5	135	137	136
Copper-D	<.002	.002	<.002	<.002	.006	.003	<.002
Iron-D	2.11	.074	.058	.135	2.6	.094	.021
Lead-D	<.04	<.04	<.04	<.04	<.04	<.04	<.04
Magnesium-D	117	52.4	54.4	26.7	89.0	39.3	36.6
Manganese-D	.445	.153	.068	.011	.146	.003	<.001
Mercury-D	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004
Molybdenum-D	.131	.011	.009	<.009	.049	<.009	<.009
Nickel-D	.094	<.006	<.006	<.006	<.006	<.006	<.006
Potassium-D	8.9	1.9	1.8	1.4	16.4	2.2	2.4
Selenium-D	<.04	<.04	<.04	<.04	<.04	<.04	<.04
Sodium-D	30.0	17.8	11.2	69.7	53.8	11.1	14.5
Zinc-D	.115	.028	.038	.024	.058	2.19	.046
Chloride	4.06	1.99	1.52	1.27	7.30	3.60	3.28
Fluoride	.78	.61	.43	2.17	.93	.26	.24
Sulfate	474	86.5	119	43.1	279	202	222
NO_3+NO_2-N	101	<.1	<.1	<.1	198	.80	.74
o-Phosphate	<.01	<.01	<.01	<.01	0.06	<.01	<.01
Conductance	2140	795	769	627	2640	852	862
TDS	1450	487	487	342	1600	620	626

TABLE 3.3-1
(Concluded)

Analyte	LFM-1	LFM-2	LFM-3	LFM-4	LFM-5	Spring	BRWELL
	Samples						
TSS	3.6	5.3	4.1	14.2	209	5.3	2.6
Ammonia	40.4	.2	.2	<.1	90.3	<.1	<.1
pH	7.91	8.03	7.94	8.09	7.90	7.61	7.94

Notes:

1. For locations of underground samples LFM-1 through LFM-4, See Figure 1-3 Appendix *B*. LFS-5 (mine sump) is located just inside portal. Spring location and bedrock well (Sample BRWELL) (Mine Supply Well) shown on Figure 2-14.

2. LFM-1, 2, and 3 are mineralized zone samples; LFM-4 is from unaltered limestone. Adapted from Lamefoot Plan of Operations and Update, July 1993.

3. All units in mg/l, except for conductance reported in umhos and pH in standard units.

4. Samples collected March 17, 1993.

Source: Echo Bay 1993a.

3.3.3 Baseline Conditions 1992-1993

Activities conducted during the exploration phase that are pertinent to geochemistry include:

- Development of the mine workings
- Completion of additional exploration drill holes
- Placement of waste rock stockpiles on the ground surface

At the mill and tailings area, similar exploration phase activities include:

- Operation of the mill and tailings pond
- Placement of ore stockpiles on the land surface
- Sampling and analysis of monitoring wells and the tailings leak detection system

Geochemical Testing

The following section describes geochemical testing performed as part of several investigations between 1990 and 1994.

Golder (1992c; 1993) originally developed the Lamefoot waste characterization program as an extension of the Key Expansion Project, because of the lithologic similarities of the two sites. The principal objectives of the Lamefoot waste characterization program were to:

- Predict whether the waste rock generated during mining will potentially produce acid rock drainage (ARD)
- Predict whether the zones of sulfide bearing rock exposed in the underground workings will generate ARD
- Evaluate whether potentially acid generating lithologies and waste rock could introduce contaminants into the environment
- Optimize the mine closure design
- Optimize the temporary storage and final disposal of the waste removed from the mine.

The DEISS, Section 3.3 referred to preparation of a final report for the results of additional geochemical tests. Rather than preparing a separate report, the results are presented here in the FEISS. The acid base accounting sampling program was designed to sample lithologies which are expected to be exposed to water infiltration throughout operations and upon cessation of mining. Non-composite samples were collected between January 1993 and January 1994 and were submitted for static testing. The sampling program was conducted as follows:

- Chip samples were taken at underground locations where development workings intercepted stope boundaries and changes in lithologies (samples LFABA 1 through 11, Table C-1a, Appendix C).

- Pulp and reject samples from existing core samples were taken at locations proximal to the proposed stope walls. Emphasis was placed on the clastic east wall of the proposed stope boundaries because these lithologies were considered more likely to be acid generating (samples 1-30, Table C-1b, Appendix C).

- An additional 24 core reject samples were collected to increase the sample population so that it was more statistically significant, and to additionally test areas which would be exposed by mine development away from stope boundaries (samples 31-54, Table C-1b, Appendix C).

- Underground chip samples and core rejects were used to collect an additional 45 samples - 15 each of the limestone, intrusive, and altered limestone lithologies (samples 55-99, Table C-1b, Appendix C).

- Eleven rotary holes in the backfill quarry were sampled at 10 foot intervals. A total of 145 chip samples were collected for geochemical characterization of the backfill material (boreholes LR 1 through LR 11, Table C-2, Appendix C).

- Six composite samples of material of known acid generating potential were assembled from rejects from previous static tests and were submitted for kinetic testing (Table 3.3-2). Three of these samples represent typical clastic wall rocks from the mine. The other samples represent typical lithologies from the proposed backfill quarry. These tests were started January 31, 1994, and were completed July 1994.

Details of the Golder studies (1993) are included as Appendix B. Results from all of the geochemical testing done between 1990 and 1994 are included at the end of this section 3.3. Static lab tests were performed on Lamefoot samples to predict their ability to generate net acid. Such tests are often referred to as Acid-Base Accounting (ABA) tests (Sobek et al. 1978). Static tests typically involve measurement of the Acid Neutralizing Potential (ANP) of a sample, as well as its Acid Generating Potential (AGP). ANP is a reflection of the abundance of minerals such as calcium carbonate, siderite, or aluminum hydroxide which consume acid. AGP is dependent on the concentration of sulfide minerals, which may form acid as they oxidize. The balance between the ANP and AGP indicates the net tendency of a material to either produce or consume acid. The ABA is negative for an acid-forming sample and positive for an acid-consuming sample. The net neutralization potential (NNP) is defined as the difference between the ANP and the AGP.

ABA tests may be interpreted in several ways. Some of the most commonly used criteria are shown on Table 3.3-3. Figure 3.3-4, taken from Schafer and Assoc. (1992), is a graphical depiction of the criteria presented in Table 3.3-3. Due to inherent inaccuracies in predicting the field response of waste samples, acid-consuming samples are conservatively considered to be those with 3 times more ANP than AGP, an NNP greater than +20, or samples with very low sulfide sulfur (AP<10 tons per 1000 tons). Acid-forming samples are considered to have an NNP less than -20. The geochemical character of samples with intermediate results is uncertain (BC Research 1989; Miller et al. 1991). These criteria should be considered as rough guidelines for prediction of net acid generation from specific geologic materials. Further discussion on data applicability is presented later in this section, and in Appendix B.

Lamefoot static tests were performed at Core Laboratories, Aurora, Colorado. Details of the test procedures are presented in Golder (1993; see Appendix B), and Appendix E of the Final EIS, Kettle River Key Project Expansion (USFS 1992).

TABLE 3.3-2

SUMMARY OF COMPOSITE SAMPLES SUBMITTED FOR KINETIC TESTING

Kinetic Test No.	Samples Composited	Total Sulfur (%)
Wall Rock Samples		
LF KIN 1	LFC-097 (351'-355')	2.92
	LFC-030 (175'-185')	3.28
LF KIN 2	LFC-145 (500-510)	2.32
	LFC-069 (335-340)	1.14
LF KIN 3	LFC-307 (505-510)	0.26
	LFC-063 (416-4215)	0.11
	LFC-066 (431.5-437)	0.34
Backfill Quarry		
LF KIN 4	LR-07 (80'-90')	0.43
	LR-09 (50-60)	2.47
	LR-11 (40-50)	1.36
LF KIN 5	LR-06 (150-160)	0.3
	LR-08 (30-40)	0.15
	LR-10 (60-70)	0.73
LF KIN 6	LR-04 (30-40)	0.03
	LR-05 (10-20)	0.03
	LR-06 (60-70)	0.17

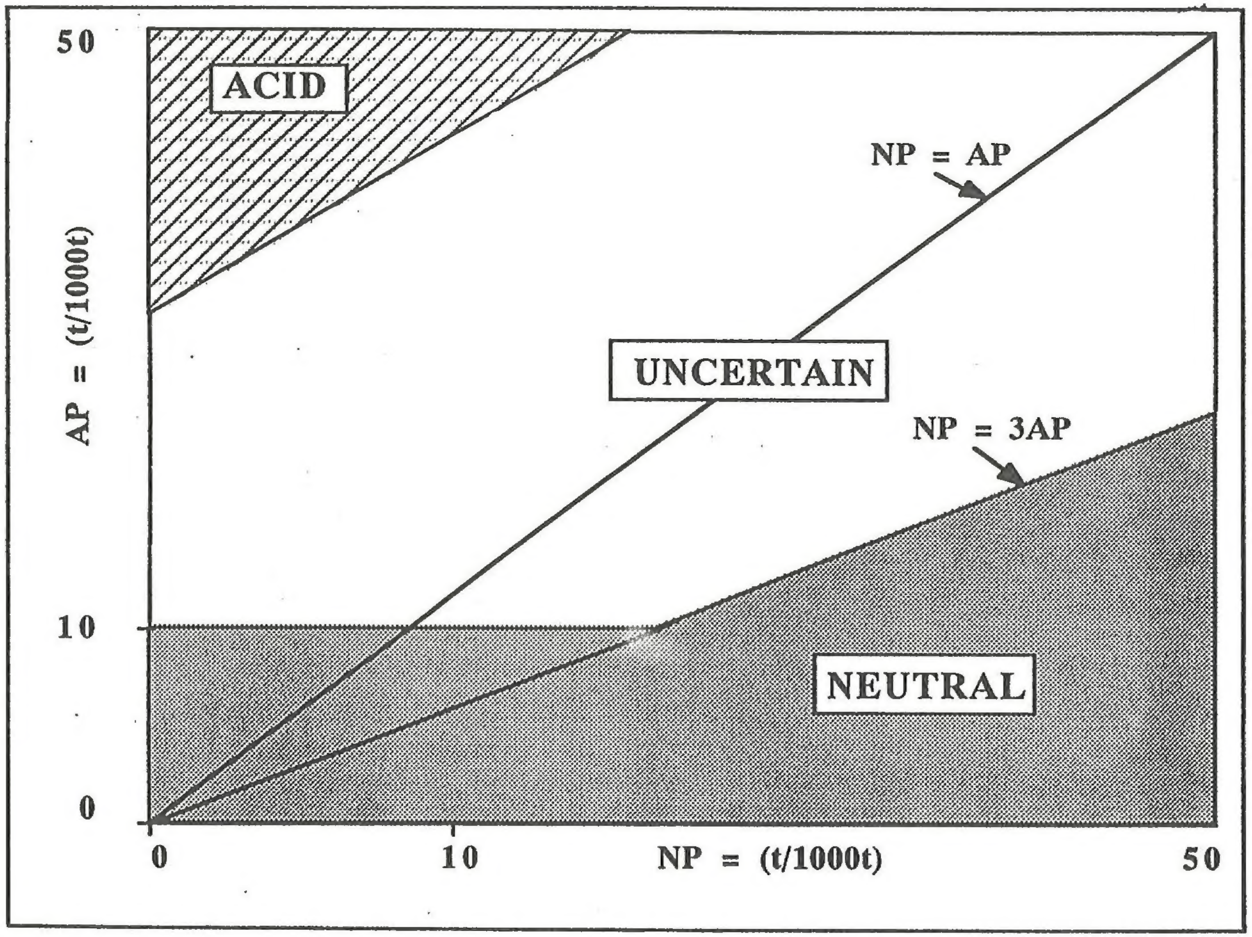
TABLE 3.3-3

EVALUATION CRITERIA FOR THE LAMEFOOT ACID-BASE ACCOUNTING ANALYSES

	NNP[1]	ANP[2]:AGP[3]
Strong Acid Generation Potential		
Group 1	NNP $<$ -20 $TCaCO_3/kT$[4]	ANP:AGP $<$ 1.0
Uncertain Acid Generation Potential		
Group 2	-20 $TCaCO_3/kT \leq$ NNP $\leq$ 20 $TCaCO_3/kT$	1.0 $\leq$ ANP:AGP $\leq$ 3.0
Low Acid Generation Potential		
Group 3	NNP $>$ 20 $TCaCO_3/kT$	ANP:AGP $>$ 3.0

1 - Net neutralization potential
2 - Acid neutralization potential
3 - Acid generating potential
4 - Acid generating potential per kiloton
T - Tons

Source: *Adapted from* Golder 1993.



TITLE
IDENTIFICATION OF ACID–FORMING AND NON–ACID FORMING SAMPLES BASED ON ACID–BASED ACCOUNT TEST RESULTS
SOURCE: SCHAFER AND ASSOCIATES, 1992

JOB NO.	DWG NO./REV.NO.	FIGURE
23295		3.3–4

Ore ABA Test Results

No ABA or other similar geochemical test results are available for the high grade ore. However, based on the estimates of percent sulfide of the various lithologies, it can be assumed that much of the ore would be acid generating (see Golder 1993; Appendix B). Assuming that essentially all of the high grade ore would be mined and milled, these materials would have little or no impact on the generation of ARD in the mine workings and the waste rock piles. Discussion of potential impacts at the tailings facility are presented in Section 4.3.6. Low grade ore results are presented in the following section.

Waste/Mine Wall Rock ABA Test Results

A total of 110 waste/mine wall rock samples were analyzed for ABA characteristics. Sample locations are shown on Figure 3.3-5. Descriptions of these samples and their locations are presented on Tables C-1a and C-1b (revised from Golder 1993). The format of the first 11 sample descriptions in Table C-1a differs from that of the next 99 in Table C-1b because they were collected at different phases of the project between 1990 and 1993. Some sample numbers are located at more than one place on Figure 3.3-5. Since many of the exploration holes are not vertical, samples from different elevations plot at different locations. The 11 LFABA samples were collected at the stope boundary. The remaining 99 samples shown on Table C-1b were collected as described. ABA test data for the 110 waste/mine wall rock samples are shown on Table C-3 (see Appendix C). Table 3.3-4 summarizes these ABA data as compared to the evaluation criteria.

The waste/mine wall rock ABA data indicate that:

- Approximately 54 to 63 percent of the clastic samples have a potential to generate acid (Group 1 in Table 3.3-3).
- Samples of the other lithologies show negligible acid generation potential (Group 3 in Table 3.3-3) and significant amounts of neutralization capacity.
- Group 3 lithologies represent 67 to 74 percent of the total waste rock volume.
- Samples with potential for acid generation make up about 22 to 26 percent of the total waste rock volume (Groups 1 and 2).
- Total sulfur concentrations for the clastic samples ranged from 0.11 to 8.4 percent (Table 3.3-5). These sulfur concentrations are significantly higher than those for clastic samples from the Key Expansion site (Golder 1993).

Quarried Backfill ABA Test Results

One hundred forty-five backfill samples were collected from 11 boreholes (LR1 through LR11) located in the area of the existing Wolfe Camp Road quarry. (Locations of boreholes are shown on Figures 3.3-6 and C-1 through C-8, Appendix C). Geologic descriptions for these backfill samples are shown on Table C-2, Appendix C). The majority of the quarried backfill samples are composed of clastic materials. ABA data for the backfill samples are presented in Table C-4 and C-5, and these data are summarized and compared to the evaluation criteria on Table 3.3-6.

TABLE 3.3-4

ABA RESULTS FOR THE WASTE/MINE WALL ROCK SAMPLES RELATIVE TO THE EVALUATION CRITERIA

Waste/Mine Wall Rock Lithology	Number of Samples Submitted	Geochemical Classification	Evaluation Criteria NNP[1]	Evaluation Criteria ANP[2]:AGP[3]
Limestone	26	Group 1- Strong Acid Generation Potential	0	0
		Group 2- Uncertain Acid Generation Potential	0	0
		Group 3- Low Acid Generation Potential	26	26
Low Grade Ore	7	Group 1- Strong Acid Generation Potential	0	0
		Group 2- Uncertain Acid Generation Potential	0	0
		Group 3- Low Acid Generation Potential	7	7
Clastic	35	Group 1- Strong Acid Generation Potential	19	22
		Group 2- Uncertain Acid Generation Potential	4	3
		Group 3- Low Acid Generation Potential	12	10
Intrusive	27	Group 1- Strong Acid Generation Potential	0	0
		Group 2- Uncertain Acid Generation Potential	0	0
		Group 3- Low Acid Generation Potential	27	27

TABLE 3.3-4

ABA RESULTS FOR THE WASTE/MINE WALL ROCK SAMPLES RELATIVE TO THE EVALUATION CRITERIA

Waste/Mine Wall Rock Lithology	Number of Samples Submitted	Geochemical Classification	Evaluation Criteria NNP[1]	Evaluation Criteria ANP[2]:AGP[3]
Altered Limestone	15	Group 1- Strong Acid Generation Potential	1	1
		Group 2- Uncertain Acid Generation Potential	0	3
		Group 3- Low Acid Generation Potential	14	11
TOTAL	110			

1- Net neutralizing potential
2- Acid neutralizing potential
3- Acid generating potential

Notes: NNP reprted as $TCaCO_3/kT$ (NNP per kiloton)
( ) refers to the number of samples in a particular group

Source: Golder 1993

TABLE 3.3-5

SUMMARY OF ACID-BASE ACCOUNTING RESULTS OF MINE WALL ROCK SAMPLES

		Total Sulfur (%)			AGP (TCaCO3/kT) (1)			ANP (TCaCO3/kT) (2)			NNP (TCaCOc/kT)(3)			ANP: AGP Ratio		
Lithology	**No. of Analyses**	**Range**	**Mean**	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**
Low Grade Ore	7	0.01-4.17	1.01	1.51	0.3-130	31.61	47.10	210-639	460.29	138.65	184-632	429	157	3.3-1460	352	566
Intrusive	27	< 0.01-1.	0.23	0.28	< 0.3-37.	7.07	8.88	85.8-495	196.69	100.62	84.9-495	190	99.0	6.72-1650	145	320
Clastics	35	0.11-8.4	3.39	2.56	3.4-262.5	106.05	79.98	9.6-336	81.99	56.02	-250-249	-24.1	102	0.04-16.8	2.36	3.68
Limestone	26	< 0.01-3.8	0.45	0.83	< 0.3-121	13.88	25.92	430-2260	990.04	332.71	405-2260	976	340	6.59-3500	1060	1410
Altered Limestone	15	0.14-28.7	5.08	7.23	4.4-897	158.69	225.82	292-862	526.60	138.99	-478-726	368	289	0.47-163	26.7	42.9

(1) Acid Generating Potential
(2) Acid Neutralizing Potential

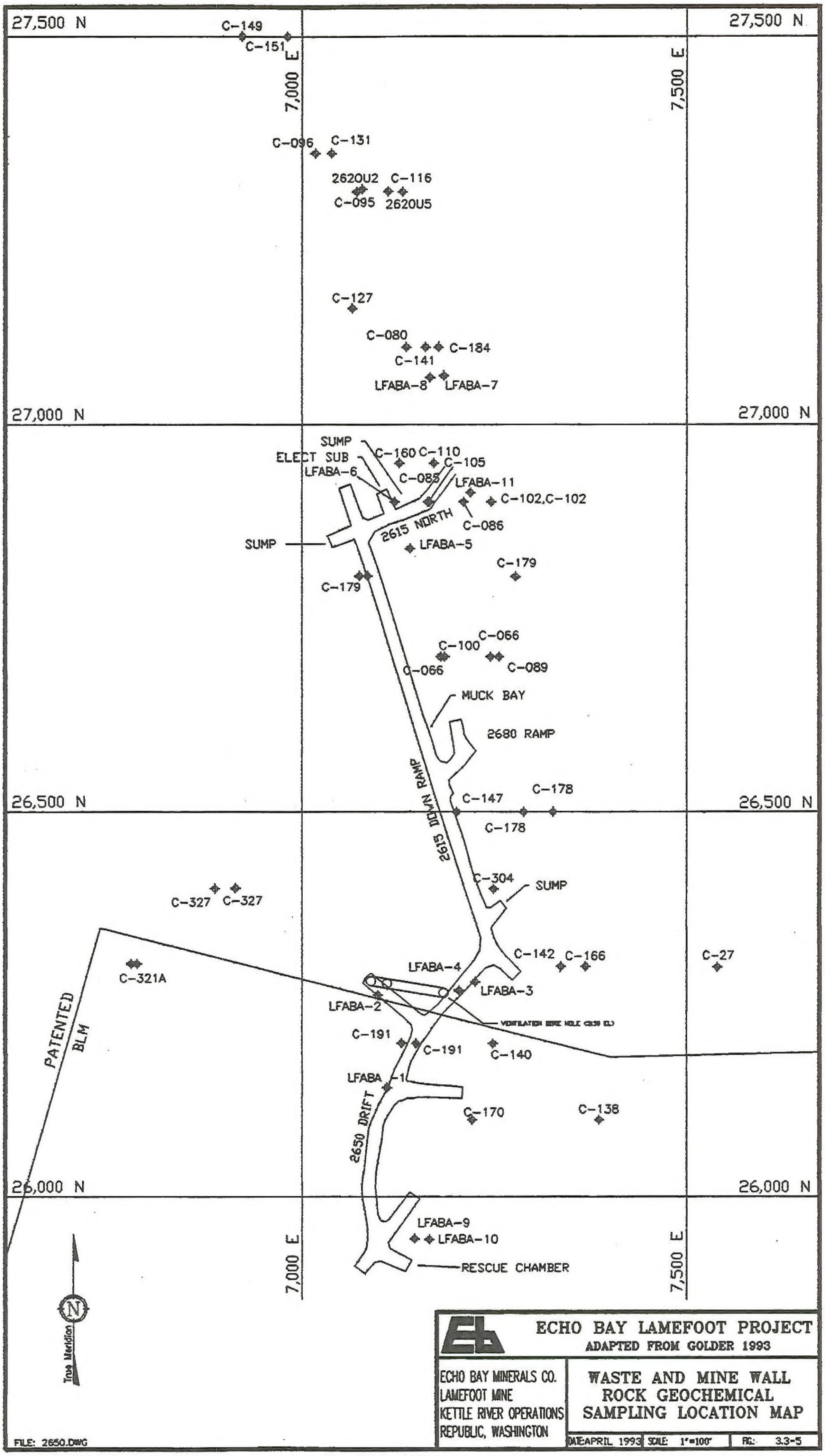
TABLE 3.3-6

SUMMARY OF QUARRY BACKFILL SAMPLES RELATIVE TO EVALUATION CRITERIA

Quarry Backfill Lithology	Number of Samples Submitted	Evaluation Criteria		
		Geochemical Classification	NNP[1]	ANP[2]:AGP[3]
Intrusive	29	Group 1- Strong Acid Generation Potential	1	1
		Group 2- Uncertain Acid Generation Potential	0	1
		Group 3- Low Acid Generation Potential	28	27
Clastic	114	Group 1- Strong Acid Generation Potential	8	19
		Group 2- Uncertain Acid Generation Potential	21	38
		Group 3- Low Acid Generation Potential	85	57
Overburden	2	Group 1- Strong Acid Generation Potential	0	0
		Group 2- Uncertain Acid Generation Potential	1	1
		Group 3- Low Acid Generation Potential	1	1
TOTAL	145			

1 - Net neutralizing potential
2 - Acid neutralizing potential
3 - Acid generating potential

Notes: NNP reported as TCaCO3/kT (NNP per kiloton)
( ) refers to the number of samples in a particular group



Eb

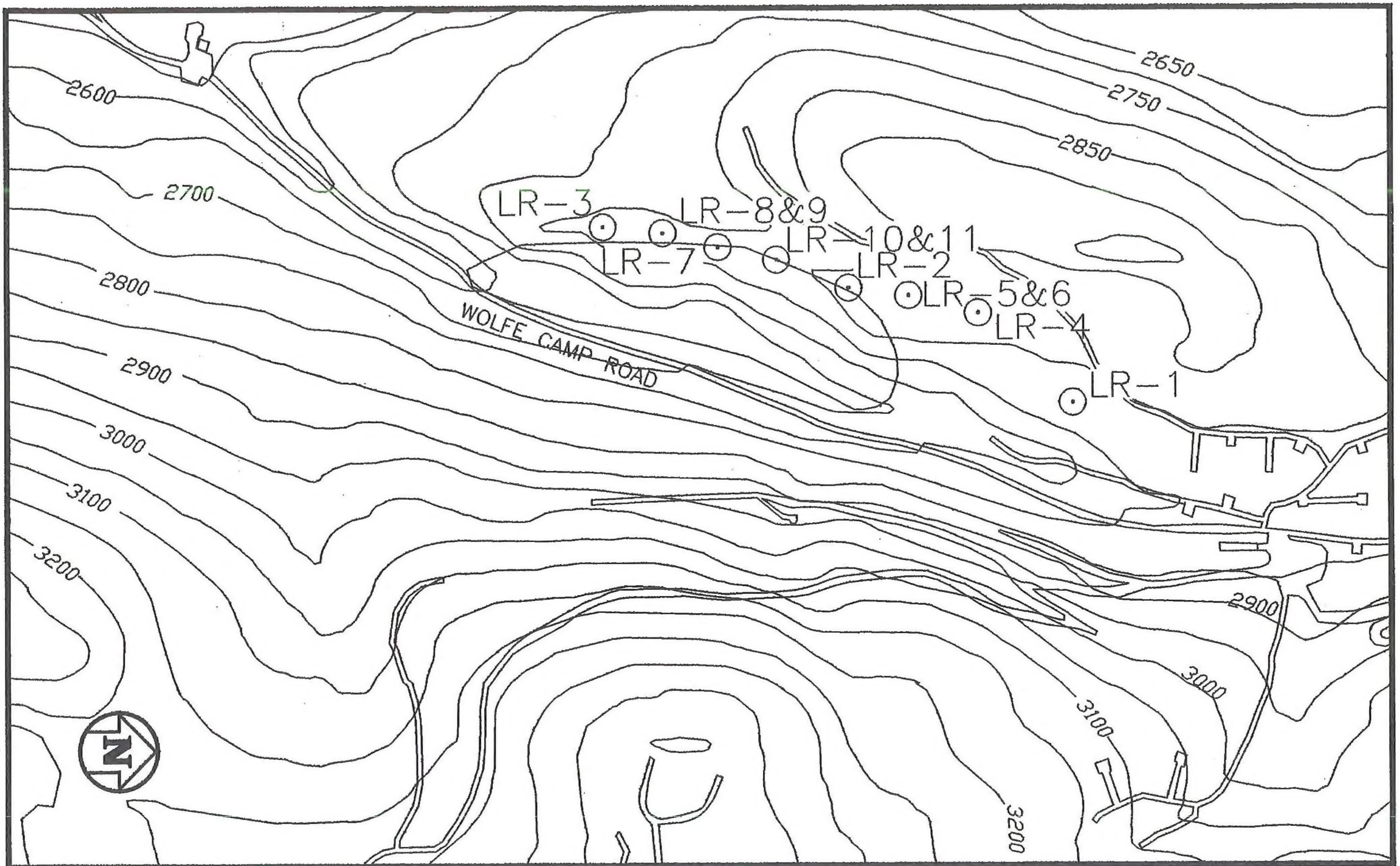
ECHO BAY LAMEFOOT PROJECT

ADAPTED FROM GOLDER 1993

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

WASTE AND MINE WALL ROCK GEOCHEMICAL SAMPLING LOCATION MAP

DATE: APRIL, 1993	SCALE: 1"=100'	FIG.: 3.3-5



CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

TITLE
LOCATION MAP OF BACKFILL EXPLORATION HOLES
SOURCE: ECHO BAY 1993c

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE:
J.H.F			NOVEMBER '93	AS SHOWN		23295		3.3-6

Quarry Backfill ABA data suggest that:

- Total sulfur concentrations range from <0.01 to 6.06 percent, with an arithmetic mean of 0.94 percent (Table 3.3-7).
- Using the ANP:AGP potential criteria summarized on Table 3.3-3, 20 samples, or 14 percent of the sample set, have a strong potential to generate acid. (Group 1). This represents 0.2 percent of the backfill material.
- Forty-one samples, or 28 percent, yield uncertain acid generation results or 42.7 percent of the backfill material. (Group 2).
- Eighty-four samples, or 58 percent, suggest they are likely to be neutralizing. This represents 57.1 percent of the backfill material. (Group 3).

New exploration holes have been drilled in the northern end of the proposed quarry. Data from these holes may change the percentages above. This northern portion of the proposed quarry comprises approximately 23 percent of the quarry backfill materials (approximately 589,479 tons). While borehole data from this zone are not yet available, visual examination indicates the materials are probably in the low acid generation potential category (see Table 3.3-3).

ABA Test Results Summary

The primary findings of the Lamefoot geochemical characterization program are:

- The majority of non-clastic waste and wall rock samples show a tendency to be neutralizing.
- ABA test results for limestone, low grade ore, and intrusive rocks from both the Key Expansion and Lamefoot sites yield comparable results (Golder 1993).
- ABA test data for clastic samples from the proposed Lamefoot mine generally show a potential for acid generation (Group 1) while those at the Key Expansion, on the whole, have an uncertain acid generation potential (Group 2). This difference suggests that results from Key Expansion testing data for clastic and mineralized zone rocks should not be used to make acid-generation predictions for comparable Lamefoot rocks.
- Selected Lamefoot backfill samples from the Wolfe Camp quarry have a potential to generate acid (Group 1). However, the bulk of the Wolfe Camp quarry materials are either acid-neutralizing or have uncertain acid-generation potential (Groups 2 and 3). The quarried backfill materials will make up about 84 percent of the total backfill to the mine workings.

Additional Geochemical Testing

Echo Bay conducted the following geochemical tests in addition to those described in the previous portions of Section 3.3:

- Kinetic testing of three composite clastic wall-rock samples. The samples were selected to show a representative range of acid generation potential. Table 3.3-2 summarizes the total sulfur percentages of the samples composited for kinetic testing.

TABLE 3.3-7

SUMMARY OF ACID-BASE ACCOUNTING RESULTS OF BACKFILL QUARRY SAMPLES

		Total Sulfur (%)			AGP (TCaCO3/kT) (1)			ANP (TCaCO3/kT) (2)			NNP (TCaCO3/kT)(3)			ANP: AGP Ratio		
Lithology	No. of Analyses	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation
Intrusive	28	< 0.01-1.1	0.14	0.27	< 0.01-36.	4.18	8.35	37-384	131.75	66.60	34-382	128	67.1	2.42-6700	974	2010
Clastic	114	0.01-6.06	1.11	1.09	0.3-189	34.79	33.89	0.1-178	84.18	46.18	-68.6-156.	49.4	48.6	0.02-75.2	5.63	10.4
Overburden	2	0.05-0.11	0.08	--	1.6-3.4	2.50	--	6.1-65.5	35.80	--	2.7-63.9	33.3	--	1.79-40.9	21.4	--
Horneblende or Altered	1	5.50	--	--	172.00	--	--	148.00	--	332.71	-24	--	--	0.86	--	--

(1) Acid Generating Potential
(2) Acid Neutralizing Potential
(3) Net Neutralizing Potential

- Kinetic testing of three composite samples of backfill material from the surface quarry. These samples were also selected from the range of acid generation potential expected to be mined from the quarry (Table 3.3-2).

- Five kinetic tests were performed on Key Expansion site samples (see USFS 1992 and Golder 1993). Echo Bay has agreed to perform further geochemical characterization as necessary during mining, as directed by BLM and Washington DOE (see Section 2.3.4). Such characterization would include additional static and some kinetic testing.

All kinetic tests were run for a total of 20 weeks (see Tables C-6 and C-7 and Figures C-9 through C-22, Appendix C). These kinetic tests were run on samples that had total sulfur contents ranging between 0.03 and 3.28 percent, and none of the samples were inoculated with bacteria. At the end of the 20 week period none of the waste rock or backfill samples showed any evidence of sulfide oxidation. All samples showed neutral to alkaline pH's with low sulfate concentrations. Dissolved iron was nondetectable by the end of 20 weeks in all samples. The somewhat higher concentrations of sulfate and conductivity during weeks 1 through 5 result from the flushing of readily soluble constituents previously contained within the samples, not the oxidation of sulfide.

Kinetic testing results are useful for qualitative screening of acid generation and trace element liberation potential of geologic materials. However, both applied experience and the technical literature suggest that these test results will not significantly improve quantitative acid production predictions. Neither ABA nor kinetic testing results have been demonstrated to be accurate or precise predictors of long-term acid generation in the field, i.e., 20 to 30 years and longer (British Columbia Acid Mine Drainage Task Force, 1989, SRK, 1992).

In an attempt to better characterize the geochemical behavior of the Lamefoot rocks, 19 additional individual samples (not composited) were collected for kinetic testing which started in early September 1994. These samples had total sulfur contents ranging between 1.27 and 28.7 percent, and the individual samples were inoculated with appropriate sulfide oxidizing bacteria prior to test initiation. The results of these tests have not been received, but will be reported in a kinetic testing supporting document to be prepared at the end of the twenty-week test period. If necessary, tests will be continued for longer than twenty weeks.

3.4 GEOLOGY AND SUBSIDENCE

3.4.1 Study Area

The Lamefoot deposit lies within a downthrown block referred to as the Republic graben. This block is approximately 50 miles long from south to north and 10 miles wide from east to west (Echo Bay 1993a). The Republic graben is one of a series of blocks, bounded on the east and west by upthrown blocks. This type of regional geologic structure is indicative of the extension of the earth's surface; in this case, the extension has been in the east-west direction.

The oldest rocks exposed within the downthrown block are Permian and Triassic sedimentary limestone and clastic (fragmental) volcanic rocks. These older rocks have subsequently been uplifted, tilted, and weakly metamorphosed (changed by heat, pressure, and water). The older rocks have been locally cut by small bodies of younger, Late Cretaceous and Tertiary igneous rocks, which solidified at depth. Minor faults generally trend north-northeasterly, roughly parallel to the major block boundary faults.

The region is a relatively low risk area for current earthquakes (i.e., renewed tectonic activity). The entire eastern Washington area lies within a seismic risk Zone 2, potentially subject to a maximum acceleration of 0.16 g and a maximum earthquake magnitude of 5.75 (Lindeburg 1990). This corresponds to a Modified Mercalli Intensity of VII, "Damage negligible in buildings of good design and construction; slight to moderate in well-built structures. Some chimneys broken" (Uniform Building Code 1991). The low level of potential seismic activity should not compromise the integrity of any underground workings or the bulkheads constructed to contain mine waters after reclamation. It is only necessary that bulkhead designs be in accordance with American Concrete Institute (1992) requirements and suitable to withstand either the maximum zonal acceleration or the maximum credible earthquake acceleration for the Lamefoot site.

The Lamefoot deposit is located within limestone and clastic rocks of Permian age, as shown on Figure 3.4-1 (Echo Bay 1993a). These rocks are steeply dipping and weakly metamorphosed. These rocks are locally intruded by rhyodacite dikes of Tertiary age. In the limestone, the ore mineralization occurs in massive sub-horizontal replacement bodies containing, in decreasing order of occurrence:

- Iron oxide, magnetite; and
- Iron sulfides, pyrrhotite and pyrite.

Ore mineralization in the clastics consists of small veins of:

- Quartz, pyrrhotite and pyrite; or
- Pyrrhotite.

Ore mineralization is also present in the clastics associated with disseminated iron sulfides. The Lamefoot mineralization is localized along a 1,500-foot length of the north-northwesterly trending Anfo Fault, as shown on Figure 3.4-1. The Anfo Fault dips steeply to the west, and has been rehealed by mineralization. The orebody appears to be divided into three approximately equal segments by two steeply south-dipping east-west trending pre-mineralization cross faults as follows:

- Southern third lies entirely within the limestone.
- Central third of the deposit has a limestone hanging well and clastic footwall.
- Northern third is entirely within clastics.

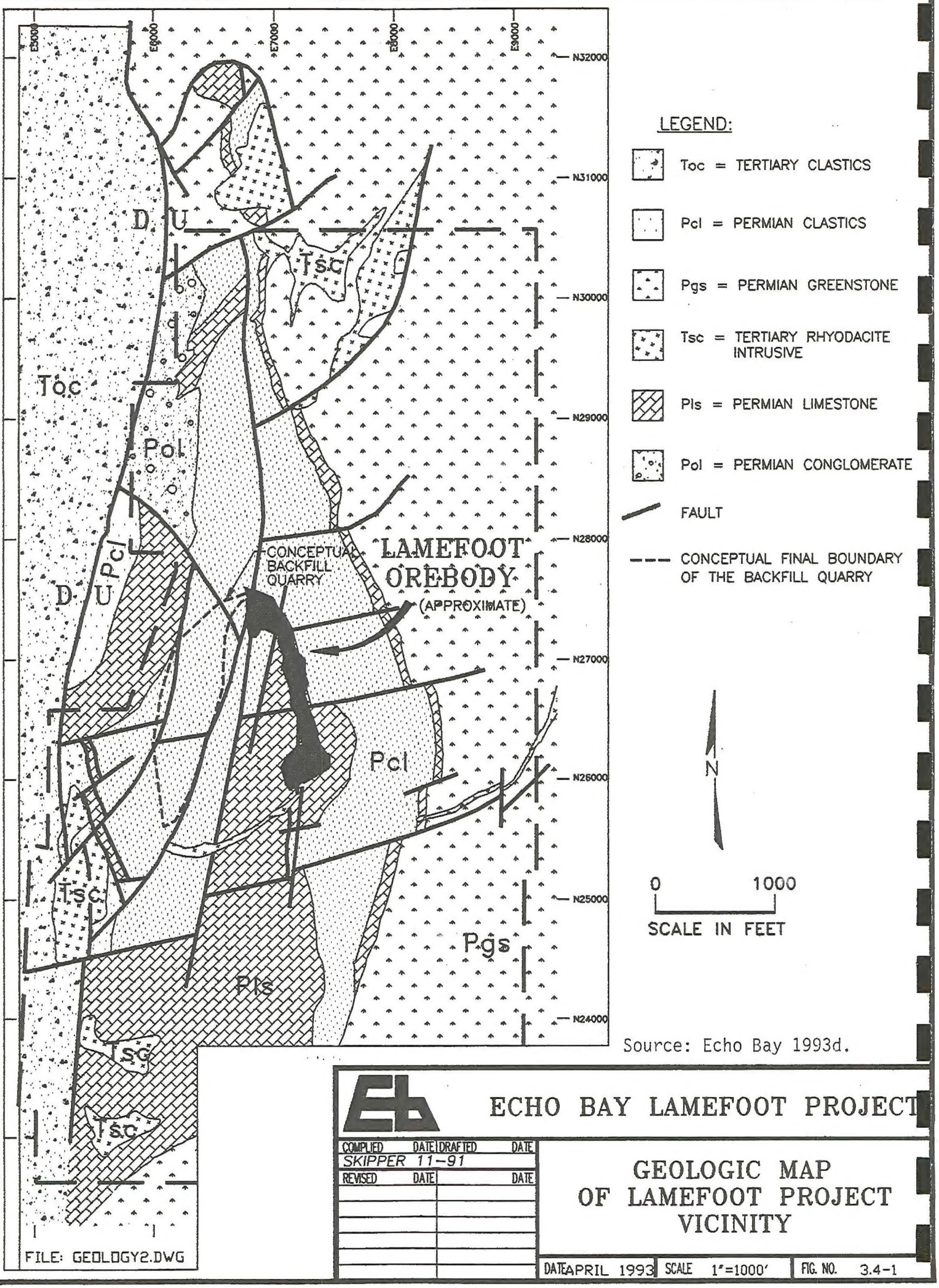
Both rock types would be classified as strong; the limestone as medium to high strength and the clastics as high strength. The volcanic clastics are, however, more closely jointed than the limestone. The more intense jointing weakens the mass strength of the clastics. Neither the Anfo Fault nor any of the faults intersecting the Lamefoot deposit are currently expected to be contributors to the approximately 7 to 15 gpm entering the exploration workings, nor can these be directly related to any surface spring.

The Lamefoot ore mineralization, as currently known, has a strike length of approximately 1,500 feet horizontally in a north-northwesterly direction. Ore mineralization is present from very near the ground surface to a maximum depth of approximately 600 feet. Such mineralization is not uniform along the Anfo Fault, but appears to vary rapidly in thickness. Further, this mineralization is highly variable in occurrence, depth, and thickness. Some parts of the Anfo Fault are unmineralized.

Minable thickness varies from 15 to 140 feet, and maximum depth from 400 to 600 feet. Figure 2-8 presents a generalized cross-section (Echo Bay 1993a). This cross-section shows a maximum minable width of approximately 100 feet and maximum vertical extent of approximately 350 feet.

A few comments concerning geohydrology and mine drainage potential are appropriate here. More details are presented in Section 3.3:

- All water samples tested, whether from the surface or from within the underground openings, indicate relatively consistent quality.



Source: Echo Bay 1993d.

ECHO BAY LAMEFOOT PROJECT

COMPILED	DATE	DRAFTED	DATE
SKIPPER	11-91		
REVISED	DATE		DATE

GEOLOGIC MAP OF LAMEFOOT PROJECT VICINITY

DATE APRIL 1993 SCALE 1"=1000' FIG. NO. 3.4-1

- The water from a natural spring approximately 600 feet north-northeast of the access tunnel portal has a slightly basic pH of 7.6.

- The water from the water supply well approximately 600 feet west of the access portal has a moderately basic pH of 7.9.

- Groundwater intercepted by the exploration workings is moderately basic, with a pH between 7.8 and 8.1.

Wolfe Camp Valley

During the planning stages for the Drop Pass Backfill Access (see Alternative 2, Section 2.4.4), a decision was made to test the rock quality and hydrological nature of the site. During March, 1994, a 500 foot core hole, LFC-432 (shown on Figure 2-20), was drilled northwesterly from the 2715 West Crosscut. This hole followed the planned trace of the proposed crosscut. Results of the drilling indicated generally fragmented rock quality in clastic rocks for the last half of the hole. Initial water discharge from the hole was approximately 6.5 gpm; however, the discharge decreased to about 3.3 gpm after 24 hrs. At 10 days the discharge stabilized at about 2 gpm (Echo Bay 1994b). The hole was abandoned and packed with a valved pipe (see Section 3.1.3).

Concern over the poor rock quality prompted the selection of another site, approximately 200 feet further north, for the supply raises. Three core holes, LFGT-1, LFGT-2, LFGT-3 (Figure 2-20) were drilled to a depth of approximately 230 feet below surface at the new location. Results of the drilling again indicated generally poor rock qualities throughout all of the holes.

Overall rock quality from the four drill holes was low enough to cause a re-evaluation of the overall backfill system. A decision was made to re-design the backfill system to take advantage of better rock conditions that exist to the east of the valley bottom. The result of this re-evaluation is the Sub-County Road Backfill Access Alternative.

Further study of data from the recent drill programs, exploration drill hole logs, and surface and underground mapping suggests many reasons for the poor rock quality in Wolfe Camp valley. The following is a geologic interpretation of those data by Echo Bay (1994a).

Stratigraphy and Mineralogy

The clastic rocks in the vicinity of the valley bottom and to the west are probably the same stratigraphic unit as those in the mine area (see Figure 2-20). They consist of thin to very thin beds of siltstone and sandstone with local lenses of conglomerate. The sediments have undergone some degree of metamorphism and therefore react to structural stress with largely brittle deformation, creating open fractures. The clastics are easily parted along bedding planes. Although the same is true for the clastic rocks near the planned stoping areas, those rocks have been mineralized with silica and most fractures and bedding planes have been "healed" by secondary deposition. Very little mineralization is found as fracture filling in the clastics west of the mine. Only occasional "crusts" of pyrite and iron oxides are evident.

There are abundant exposures of magmatic intrusive rocks in the area west of Wolfe Camp valley. These intrusives are probably late Tertiary in age and are commonly rhyodacite with varying degrees of alteration. The intrusives are generally more competent than the clastics but are well jointed and fractured.

Structure

Rocks to the west of Wolfe Camp valley are significantly more disrupted by strong faulting than in the mine area. Two major sets of faulting are noted. A N-S striking, steeply west dipping set of normal faults is cut by a NE striking, moderately NW dipping set of reverse faults. The intrusive rocks appear to be injected along both sets and in some cases were offset by later fault movement. The net effect of this intense faulting was to "shatter" the brittle clastic rocks. This zone of disruption appears to become pronounced immediately west of a high angle, normal fault that is interpreted to occur in the valley bottom.

Weathering

All of the core in the four holes drilled to test the zone showed evidence of weathering. Most fracture coatings are the oxidized product of chemical breakdown of sulfides. A deep weathering zone, possibly 200-300 feet deep, may exist below Wolfe Camp valley. Weathering out of sulfide fracture fillings appears to have contributed to the "shaley" nature of the surface outcrop on the west side of the valley. Some erosion of clay rich beds may also have occurred.

3.4.2 Baseline Conditions Prior to 1992

No underground mining-induced subsidence has occurred in the Lamefoot area (from which to build a subsidence prediction model, based on local conditions and subsidence monitoring). Previous mining activity in the immediate Lamefoot area involves one short adit, tunnel, on the ridge east of Wolfe Camp Road and above the planned mine. The Lamefoot access and exploration openings are too small, relative to the strength of the rock mass (see Echo Bay 1993a; Appendix F, Section 4.3, and Addendum 2, Section 2.2) to produce failure measurable subsidence. The use of the site-specific strength and 55 percent free swell data supplied by Echo Bay is detailed in Appendix D. Echo Bay also provided compression strength results for the rock types, as follows:

- Limestone, 16 tests, 15000 psi mean strength
- Clastics, 15 tests, 21600 psi mean strength
- Massive magnetite ore, 5 tested, 29,700 psi mean strength
- Intrusives, 6 tests, 18500 psi mean strength

These data appear to be sufficient to establish the high strength of all the rock types present. It will, however, be necessary to import subsidence experience and prediction methods from outside sources as the impacts are assessed in Section 4.4.

3.4.3 Subsidence Potential from 1992-93 Exploration Program

The Lamefoot access and exploration openings (approximately 16,500 feet of 16-foot wide by 14-foot high openings) are too small, relative to the strength of the rock mass (Echo Bay 1993a; Appendix F, Section 4.3; and Addendum 2, Section 2.2), to produce failure and too deep to produce measurable surface subsidence. This statement also applies to the ramps, crosscuts and drillholes completed during exploration. Site-specific strength and 55 percent free swell data were supplied by Echo Bay (see Appendix *D*). Echo Bay also provided compression strength results for the rock types, as follows:

- Limestone, 16 tests, 15,000 psi mean strength
- Clastics, 15 tests, 21,600 psi mean strength
- Massive magnetite ore, 5 tests, 29,700 psi mean strength
- Intrusives, 6 tests, 18,500 psi mean strength

These data appear to show sufficient testing to establish the high strength of all the rock types present, specifically with respect to (a) the potential approximate maximum 1500 psi compressive stresses present around (b) the 16-foot wide by 14-foot high exploration openings; at (c) the maximum depth of exploration openings of approximately 1500 psi. In the absence of rock failure, significantly larger openings, and shallower depths, subsidence is not likely to develop at the surface over the exploration openings.

3.5 AESTHETIC RESOURCES

3.5.1 Study Area

The objectives of the visual resource report are to identify and describe visual resources which could be affected by the proposed project. The study area includes those areas that viewers may travel through, recreate in, or reside in, where existing views may be affected by the proposed action. These would include Curlew Lake State Park and residences on the west side of the lake.

3.5.2 Baseline Conditions Prior to 1992

The 1992 Environmental Analysis of the Lamefoot Project Drilling and Exploration Program evaluated the visual resources of the Lamefoot project site. The description below is taken from that document. The Lamefoot Project Area had not been evaluated by the BLM for Visual Resource Management (VRM) classifications at the time that document was written. It has since been rated as containing both VRM Class III and IV lands, based on the baseline conditions described in the 1992 EA (Golder 1992c). Aesthetic resources were evaluated from four perspectives: composition, quality, condition and visibility.

Composition of the project scenery was assessed through the description of the four landscape elements of line, form, color and texture. Texture and color were found to exert stronger influences on the composition of the landscape than either line or form. Forms are rounded rather than angular; lines are horizontal rather than vertical. Color elements are derived primarily from vegetation, and the diverse vegetative mosaic contributes strongly to the textural elements of the landscape.

Quality of scenic resources were rated as moderate. The site has no large geological or water features, or dramatic variations in colors that are associated with areas having higher visual appeal.

Condition of the site was mostly undisturbed, except for an existing gravel pit and exploration drill roads, which heavily impacted the restricted viewshed from the Wolfe Road. Most of the disturbed area could not be seen from viewpoints outside of the Wolfe Camp drainage except for the upper drill road, which is visible from many vantage points surrounding the Lamefoot site. Because of the topographic and vegetative screening of most of the disturbance areas, the project site appeared only slightly disturbed from most key observation points.

Visibility of the study area was evaluated from State Highway 21, Wolfe Road, Curlew Lake State Park and from nearby residential areas, primarily on the west side of Curlew Lake. The project area is generally in the foreground-middleground viewshed from most viewing locations within the study area. However, some areas within the project site (particularly the areas of proposed disturbance in the Wolfe Camp drainage) are topographically screened from the view of most observers, except travellers on the Wolfe Road itself. Figure 3.5-1 displays the topographic visibility of the project area (or seen/not seen areas) from local vantage points.

Travelling north on State Highway 21 from the junction with State Highway 20, the project area is initially visible near the junction of County Road 284 (Fish Hatchery Road). The south facing slopes on the toe of the ridge above and to the west of the existing gravel pit are visible. Approaching the Wolfe Road, the project area becomes highly visible from the highway. Once past the entrance to Curlew Lake State Park, the project area becomes screened from view by topography.

There are five residences that use the Wolfe Road for access. The road also receives light recreational use, especially during the fall hunting season. On the lower section of the road views are restricted by the narrow canyon to the immediate foreground. As the road leaves the drainage the slopes are more gentle but the views are mostly blocked by thick coniferous vegetation. At approximately 3,000 foot elevation, the road passes over a saddle and turns toward the east, becoming visually removed from the proposed actions.

County Road 203 (W. Curlew Lake Road) provides access to resorts and residences on the west side of the lake. Travelling north on 203, the project area is initially viewed near the junction with County Road 270. Continuing north, the west facing slopes in the project area are occasionally visible. In the vicinity of Barrett and Trout Creeks the views to the east include much of the project area. Visibility of the project area north of the Trout Creek Road is low.

Curlew Lake State Park is located west of State Highway 21, directly across the highway from the project area. The most eastern portions of the park have extensive views of the project area. However, as one goes into the park towards the campground, picnic areas and boat launching facilities located around the lakeshore, there is a drop in elevation. Because of this, intervening topography screens most views of the site from the actual recreation areas within the park.

Across the lake, the small residential development at Pollard is almost directly west and slightly more than one mile from the center of the project area. Views from Pollard to the site are towards the southeast, which causes the west and northwest facing slopes to be the most visible. Pollard does not have views into the Wolfe Camp drainage. Other residences scattered along the west side of Curlew Lake between Barrett and Trout Creeks have the most exposure to activities at the mine site.

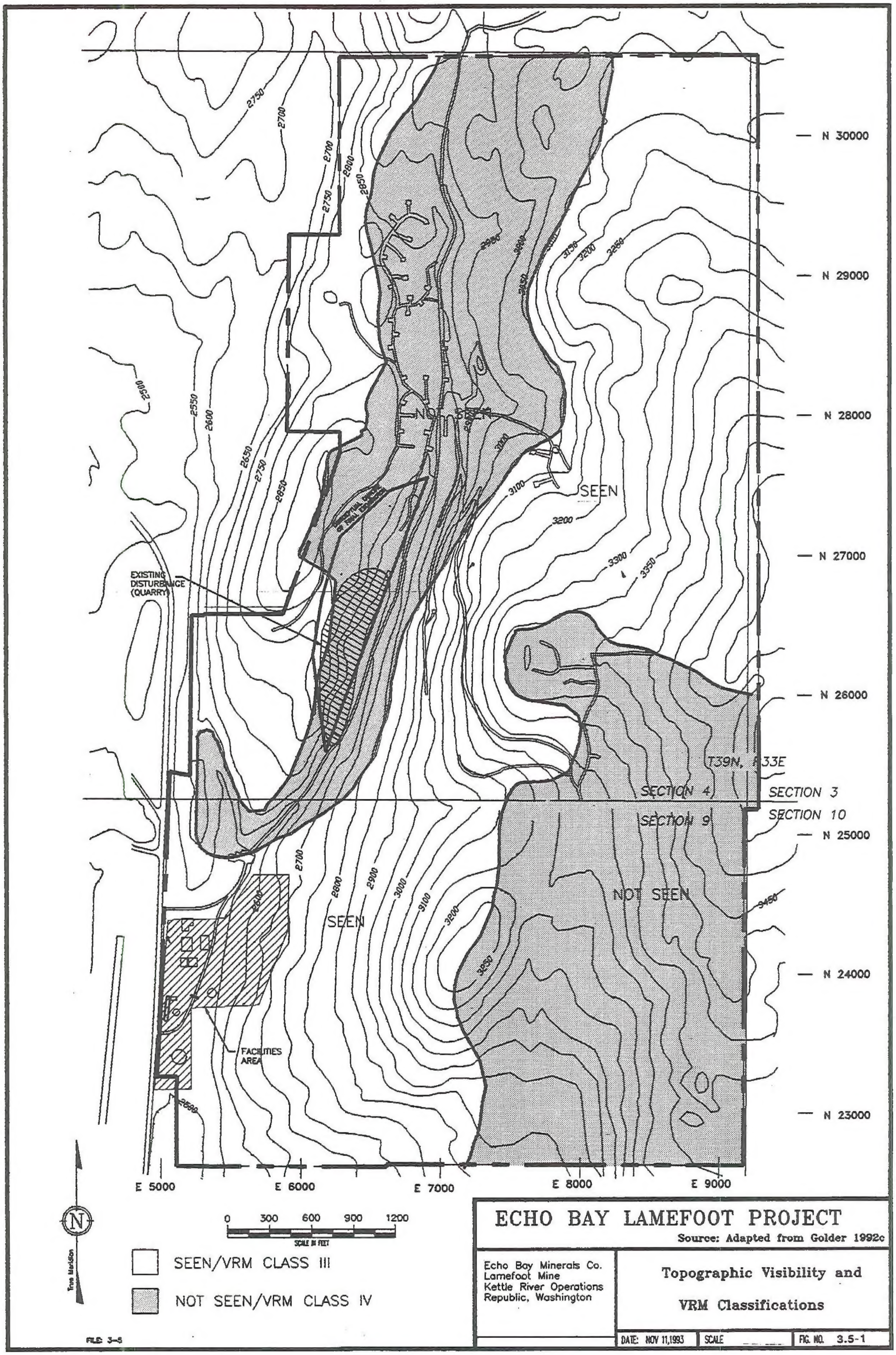
3.5.2.1 Key Mill

The 1988 FEIS for the Kettle River Project described the Key Mill site as being located on relatively level benches approximately 50 to 150 feet above the North Fork of the Sanpoil River. The area was vegetated with primarily irrigated crop land and scattered Douglas Fir on the lower bench. The site contained farm buildings and structures which would be removed for the mill construction. The mill site is located in a remote area that is not visible from major roads or residences. The site may be visible through breaks in the vegetation from the Kettle Crest Trail, located several miles east of the site. No major visual impacts were predicted as a result of the construction of the Key Mill.

3.5.3 Baseline Conditions 1992-1993

This section describes the visual resources of the Lamefoot site as it currently exists, taking into account the exploration activities that were the subject of the 1992 EA. The description of the visual resources of the study area are based on the methodology described in the Bureau of Land Management's Visual Resource Inventory Manual (BLM 1986a).

Based on an inventory of the project area's scenic quality, sensitivity and distance from key observation points, and taking into account other RMP (Resource Management Plan) land use allocations, landscapes are placed into one of four VRM classes I to IV, with Class I objectives being the most protective of the visual resource of the landscape, and Class IV objectives allowing more disturbance. Table 3.5-1 describes the VRM objectives for all of the four VRM classes. The Lamefoot site contains both VRM Class III and IV lands, depending on topographic visibility and levels of disturbance existing on the site prior to exploration activities. Figure 3.5-1 shows the VRM classes within the project area.



ECHO BAY LAMEFOOT PROJECT

Source: Adapted from Golder 1992c

Echo Bay Minerals Co.
Lamefoot Mine
Kettle River Operations
Republic, Washington

Topographic Visibility and VRM Classifications

DATE: NOV 11,1993 SCALE FIG. NO. 3.5-1

TABLE 3.5-1

VISUAL RESOURCE MANAGEMENT OBJECTIVES

1. Class I. The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.

2. Class II. The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

3. Class III. The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

4. Class IV. The objective of this class is to provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

Source: U.S. Bureau of Land Management 1986a.

Much of the visual descriptions given above in Section 3.5.2 are still valid; this section will reference Section 3.5.2 when appropriate, and focus on a discussion of those elements in the landscape that have changed from the baseline condition.

3.5.3.1 Scenic Quality

The Lamefoot project area is located in the mountainous area between the Selkirk and Okanogan Valleys known as the Okanogan Highlands, which is part of the Northern Rocky Mountain physiographic province (Fenneman 1931). Topography of this region was heavily influenced by repeated glaciation, which resulted in lower elevations, more moderate slopes, and summits more broad and rounded than other mountains in the region that were not subjected to continental glaciation.

The Lamefoot site is located along the lower slopes of mountains that run in a north-south direction on the east side of the Curlew Lake Valley, and is typical of landscapes found within the region. Landforms include glacial terraces, the toes or terminations of ridges and drainages. Although the site contains some steep slopes, the overall form of the terrain would be characterized as being rounded rather than angular. Vegetation on the site is primarily Douglas fir and ponderosa pine, interspersed with grasslands and small shrubs. Drainages also contain plant species associated with moist conditions such as cottonwoods and willows. This diverse vegetative mosaic with its associated variety of color and texture is the strongest visual element of the site. The project area is adjacent to Curlew Lake which adds to the visual qualities of the site. Overall, the scenic quality of the Lamefoot project area would be considered moderate, compared to other landscapes found within its physiographic region.

Mining exploration activity has impacted the natural appearance of the site. This existing disturbance includes roads, a mine portal, waste rock storage stockpiles, and several buildings and ancillary structures. An old gravel pit, not associated with the current mining activity, has disturbed several acres of land along the lower portion of Wolfe Camp Road. The most visible components of the existing disturbance include the waste rock stockpiles, the portal and its surrounding area, and sections of the upper exploration drill road. Parts of these facilities or areas of disturbance can be seen from State Highway 21 and from several locations around Curlew Lake. The light color of exposed soil and waste rocks contrasts with the generally darker color of the surrounding vegetation, which causes these areas to be highly noticeable. The waste rock stockpiles also introduce new line and form contrasts to the natural surrounding landforms. The scale of this existing disturbance has, so far, not substantially reduced the natural appearance of the larger landscape surrounding the lake. However, it has impacted views directed at the project area itself, especially for travellers along State Highway 21 who pass directly in front of the facilities. With mitigation, the site meets VRM Class III and IV objectives.

3.5.3.2 Sensitivity

State Highway 21 is a major road in the area, providing access to local residences and recreation areas around the lake, and is used as a thoroughfare to Canada. Curlew Lake State Park is located directly across State Highway 21 from the project area - several resorts and many private residences also can be found along the lake, including Pollard, a small residential community on the west side of the lake. Based on the number and type of viewers, and the recreational and residential environment of adjacent lands, the area would be considered to have a high visual sensitivity.

3.5.3.3 Visibility and Distance Zones

Distance zones are delineated from travel routes or other sensitive viewing locations such as residences or recreational areas. The description of site visibility is the same as described in Section 3.5.2. The project site is within the foreground/middleground distance zone, except for areas within the Wolfe Camp drainage, which are in the seldom-seen distance zone from most key observation points within the study area. Views of the project site now include facilities associated with the exploration phase of the project, including the waste rock stockpiles, buildings and other ancillary structures as described under the scenic quality section.

3.6 TRANSPORTATION

3.6.1 Study Area

The study area for the transportation resource includes state and county roads affected by exploration or mining activities associated with the Lamefoot project (Figure 1-2). Roads in the study area that provide access to the Lamefoot project site or to the Key Mill include State Highway 21, Wolfe Camp Road (County Road 273), Old Kettle Falls Road (formerly known as Cooke Mountain Road) (County Road 280), Fish Hatchery Road (County Road 284), and Jack Mays Pride Road (County Road 287).

3.6.2 Baseline Conditions Prior to 1992

The following description of the baseline condition of the transportation network affected by the Lamefoot project is based on discussions of these roads included in the 1988 Kettle River Project FEIS (State of Washington DOE 1988), the 1992 Kettle River Key Project EIS (Golder 1992d) and the 1992 Final Environmental Analysis of the Lamefoot Project (Golder 1992c).

State Highway 21 is the major road in the study area providing access from the Town of Republic north to Curlew Lake and to most Kettle River Project facilities. In 1986, traffic counts on Highway 21 were 1,000 vehicles south of the intersection with Fish Hatchery Road/ West Curlew Lake Road and 675 vehicles north of the intersection. Where West Curlew Lake Road rejoins State Highway 21 north of Curlew Lake, traffic counts were 700 vehicles south of the intersection and 1400 north of the intersection. Traffic counts on State Highway 21 remained in the 1,200 to 1,400 range until the junction of Highway 21 with West Kettle River road. North of that intersection traffic counts dropped to 750 vehicles a day.

The Old Kettle Falls Road provides access from State Highway 21 east to its junction with Jack Mays Pride Road, a distance of just over 2 miles. The road is paved with a 60 foot right-of-way. Although not an all-weather road, Ferry County has recently upgraded this road to all-weather status.

Jack Mays Pride Road is approximately .9 miles in length and connects Old Kettle Falls Road with Fish Hatchery Road. The graveled road has a right-of-way that varies from 60 to 100 feet. Portions of the road had been improved by Echo Bay.

Fish Hatchery Road, a gravel road with a 60 foot right-of-way, runs east from its junction with State Highway 21 to the Key Mill. Although portions of the road have been rebuilt, it would need additional work for use by mine traffic.

The Ferry County Airport is located on the west side of State Highway 21, just south of the Lamefoot site. It has one 3,500-foot runway, which is capable of landing small charter and private planes.

3.6.3 Exploration Activities

This section describes the current condition of the transportation network affected by the proposed action. It will focus on those items that have changed since the exploration phase at the Lamefoot Mine have taken place.

3.6.3.1 State Highway 21

State Highway 21 is the major road in the study area providing access from the Town of Republic north to Curlew Lake and to the Lamefoot Project site. The highway continues north to the Canadian border. It is a two-laned, asphalt paved road with an average width of 22 feet. Under the proposed action, the section of State Highway 21 between Wolfe Camp Road (MP 144.05) and the Old Kettle Falls Road (MP 139.13) would be used as part of the haul route for ore transport between the mine and the Key Mill. For the alternative haul route, traffic would turn off State Highway 21 at the Fish Hatchery Road junction.

The Washington Department of Transportation (WDOT) describes portions of State Highway 21 along the haul route as narrow, twisting and with insufficient surfacing that may require weight restrictions in the winter/early spring period. Weight restrictions can last for one to two months and, when "severe emergency" restrictions are in place, stops all haul traffic. This has not occurred in the last several years, but these types of restrictions could take place. At times, the roadbed condition does not require the stopping of all heavy truck traffic, but may require reduced truck weights. Conditions are monitored by WDOT personnel, and vary from year to year.

Currently, WDOT has planned a construction project on State Highway 21 between MP 138.37 and MP 141.67 that will realign several curves, channelize intersections, and resurface the roadway. This project, which will bring that section of the road up to all-weather standards, is scheduled to occur in 1995. Figure 1-2 shows the section of Highway 21 where these construction activities will occur. During construction, traffic will be reduced to one lane around the portion of highway under construction with flagmen controlling traffic flow.

Twenty accidents occurred on State Highway 21 between MP 139.13 (Old Kettle Falls Road) and MP 144.05 (Wolfe Camp Road) during a period from January 1987 to September 1992, for an average yearly accident rate of 3.48 accidents/year. Average Daily Traffic (ADT) along State Highway 21 south of the junction of Old Kettle Falls Road was 1,950 and 1,700 north of the junction. ADT south and north of the junction of Wolfe Camp Road was 1,140 and 1,090, respectively. South of the junction of West Kettle Road ADT was 1,190, and 1,000 north of the junction (WDOT 1993).

3.6.3.2 Wolfe Camp Road

The primary access into the Lamefoot site is the previous alignment of Wolfe Camp Road, which was vacated by the county during January, 1993. The new entrance to Wolfe Camp Road is located just north of the Lamefoot mine entrance and provides access for local residents. This road has a gravel surface which averages about 20 feet in width. The road has been used for surface exploration drilling and for access to exploration drill roads built to the east and above the Wolfe Camp Road. During construction of the exploration drill roads, blasted rock was deposited downslope which now forms a talus slope above portions of the Wolfe Camp Road. The slope has been netted with chain link fence for stabilization.

The proposed action would relocate the Wolfe Camp Road west of the existing alignment upon project completion. Figure 2-7 shows the preliminary plan for diversion of the road. The relocated alignment would be in the area proposed for excavation for backfill material. The realignment would occur in phases to coincide with the progress of the excavation.

Phase I would occur within one year of commercial production. Phase II would be constructed as backfill requirements dictate. Phase III would complete the relocation of Wolfe Camp Road. As part of the relocation plan there would be an intersection between the Wolfe Camp Road and a road used by Echo Bay to haul backfill material from the excavation site to the mine. Haul traffic would be controlled at the intersection with the use of stop signs (i.e., the stop sign will stop mine traffic, not the county road traffic). An alternative has been developed which would move backfill material from the excavation site to the mine via an underground tunnel, which would eliminate the need for surface transport of backfill across the county road.

The Ferry County Road Department will design the new road configuration to county standards; Echo Bay will build it. Echo Bay will also reimburse the county for any engineering costs associated with the project.

3.6.3.3 Old Kettle Falls Road

Old Kettle Falls Road (County Road 280) is part of the proposed haul route. Built in 1952, it is a paved two-laned road approximately 24 feet wide. In 1992, the road was widened and resurfaced to all-weather design standards from MP .16 to MP .99. Similar improvements to the road have been made during 1993 which has completed upgrading of the road to all-weather condition for all of the section to be used as part of the haul route. Scheduled work in 1994 includes applications of a rock chip and seal coat to improve traction. Average Daily Traffic in 1989 was 436 vehicles. One accident was reported in 1992 at MP 5.92.

3.6.3.4 Jack Mays Pride Road

Jack Mays Pride Road (County Road 287) is approximately 0.9 miles in length and connects the Old Kettle Falls Road with Fish Hatchery Road. It is a gravel road with a right-of-way that varies from 60 to 100 feet. Portions of the Jack Mays Pride Road were recently reconstructed by Echo Bay.

3.6.3.5 Fish Hatchery Road

Fish Hatchery Road (County Road 284) runs east from State Highway 21 at Torboy. The portion of the road being used as part of the proposed haul route begins at the intersection with Jack Mays Pride Road and continues east for approximately one-half mile to the Echo Bay security gate. The alternative haul route would use the Fish Hatchery Road from its junction with State Highway 21 east to the Key Mill. Some Echo Bay employees use this section of road for access to the mill site. It is a gravel surface road approximately 20 to 22 feet in width. Average daily traffic was 170 vehicles in 1989. There were no reported accidents in 1992. If selected as a primary haul route, the road would need widening, paving, and some realignment to improve sight distance which would require the purchase of adjacent private land.

3.7 NOISE

3.7.1 Study Area

The objective of the noise assessment is to identify and describe increases in noise levels which could be affected by the proposed project. The study area includes those areas that receivers may travel through, recreate in, or reside in, where existing noise levels may be affected by the proposed action. This area would include Curlew Lake State Park and residences on the west side of the lake, and residences along the proposed ore transportation routes.

Ambient noise is defined as the level of sound associated with a given environment resulting from composite sounds from many sources, near and far. Typical sources of ambient noise currently affecting the Lamefoot Project Study Area include:

- Exploratory drilling operations
- Heavy equipment
- Automobiles
- Trucks
- Noise emanating from buildings
- Airplanes
- Wildlife activity
- Wind (rustling brush or leaves)
- Flowing water

Natural sources of noise include:

- Wind
- Rain
- Thunder
- Insects
- Birds
- Other wildlife

Decibels

The scale for measuring noise levels are decibels (dBA). The scale is logarithmic to accurately correspond to auditory perception of increasing loudness and to encompass the large dynamic range which the human ear is capable of perceiving. This logarithmic scale means the following:

- An increase of 3 dBA represents a doubling of the noise level.
- Zero dBA represents the threshold of hearing.
- Conversational speech at 1 meter represents a noise level of 60 dBA.
- An aircraft taking off is about 120 dBA.
- Recreational water craft noise levels at 50 feet range from 65 dBA for small outboard motors to 95 dBA for high horsepower outboard crafts.
- Chain saw activities at 50 feet range from about 90 to 110 dBA.

The EPA has established a guideline of 70 dBA to protect public health and welfare with a margin of safety.

Washington State Noise Standards

The Washington State noise standards are contained in Chapter 173-60 WAC. The basic requirements for all project facilities at the receiving property line are the following:

- Noise levels not to exceed 60 dBA during daytime hours, and 50 dBA from 10 pm to 7 am.

- Increases of 5, 10, and 15 dBA for 15, 5, and 1.5 minutes respectively, are allowed during any hour of the day or night.

- Increased noise levels, however, resulting from blasting of earth materials in support of mining or construction activities are entirely exempt between the hours of 7 am to 10 pm; however, surface blasting for this project would be scheduled no more than twice a week, at the same time of day, in the early afternoon.

- Construction noise is exempt from 7 am to 10 pm only. (Note: the regulation does not specify that noise associated with mining activity is classified as construction noise).

- Motor vehicles operated off public roads are not exempt.

- Motor vehicles on public roads are regulated separately.

- Noise levels of watercraft at 50 feet are not to exceed 84 dBA if manufactured before 1980, 82 dBA if manufactured between 1980 and 1984, and 80 dBA if manufactured after 1984.

3.7.2 Baseline Noise Conditions

Available data indicate that noise levels in natural environments such as the study area may range from 15 decibels (dBA) up to 45 or 50 dBA, depending upon the naturally occurring noise sources. The proposed Project Area is situated adjacent to a primary roadway (State Highway 21) and to Curlew State Park which is located within one-half mile of the site.

3.7.3 Noise from Exploration Activities and Mill Operations

Public scoping meetings have shown the potential for public concerns for noise impacts from commercial mining at the site. Thus, a noise survey was conducted to assess the current background noise levels associated with the natural environment, with nominal human activities (aircraft overflights from the nearby airfield, boating on Curlew Lake, and vehicular traffic), and with Lamefoot exploration and development work.

Noise Level Survey

The noise level survey was conducted over a four-day period from March 16 to March 19, 1993, and includes three daily measurements: morning, mid-day, and afternoon/evening surveys. Conducting the survey accomplished two objectives:

- Obtained normal background noise levels at the Lamefoot property line as required by state regulations (Chapter 173-60 WAC)
- Collected noise level data at the locations with potentially higher noise levels on the project site

An additional monitoring site was selected in the Pollard residential area on the western side of Curlew Lake at its closest point to the Lamefoot site. Eight monitoring stations were chosen; five along or near property lines, two on the site itself, and the Pollard location as shown on Figure 3.7-1. Raw data collected during the noise survey are presented in the Lamefoot Plan of Operation (Echo Bay 1993a).

Natural background sound levels at each of the eight stations, unimpacted by barking dogs (at Pollard only), vehicular traffic, and current activities at the Lamefoot site, were recorded at less than 40 to 41 dBA.

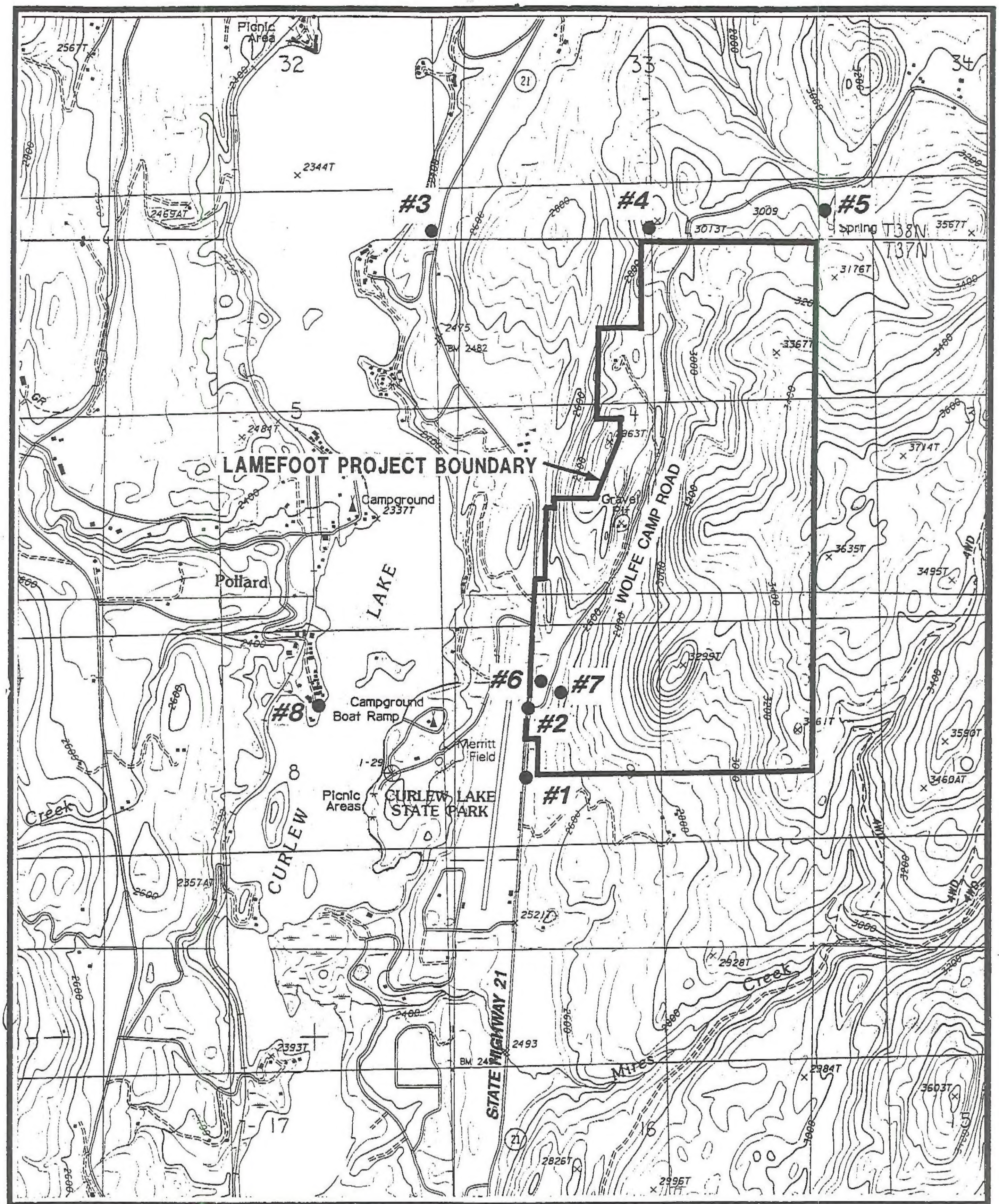
Highest Peak Noises

The highest peak noises were recorded adjacent to Highway 21:

- Passing cars produced peaks of 68 to 75 dBA.
- Pickup trucks produced peaks of 72 to 84 dBA.
- Large trucks produced peaks as high as 87 dBA.

The highest sustained sound levels were recorded at the exhaust collar of the ventilator shaft at 91 dBA. Noise dropped rapidly with distance from the exhaust collar, no doubt due to the vertical collar projecting sounds upward and not radially outward.

- At a distance of 50 feet from the exhaust collar, the sound level was recorded at 58 dBA.
- At 200 feet, the sound level was recorded at 43 dBA.



CLIENT/PROJECT	ECHO BAY MINERALS Co. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON
DRAWN	CHECKED J.C.
REVIEWED L.E.C	

TITLE

LAMEFOOT PROJECT
NOISE MONITORING LOCATIONS

SOURCE: ECHO BAY, 1993a

DRAWN BDL	DATE APRIL 1993	JOB NO. 933-2614
CHECKED LEC	SCALE 1"=2000'	DWG NO./REV. NO.
REVIEWED SHM	FILE NO.	FIGURE NO. 3.7-1

- At a distance of 400 feet during the 2 hours (1:00 pm to 3:00 pm) when the readings were taken, the sound of the ventilator was barely audible above the natural background noises.

Because elevated noise measurements were taken at the exhaust shaft, a wooden containment structure border has been constructed in order to mitigate ambient noise levels by directing sound upwards.

Lamefoot site activities recorded included loaders working on the waste rock stockpiles, underground mobile equipment moving in and out of the mine, personnel transports, haul trucks, and ladders. Peak sound levels ranged between 44 and 61 dBA for those site activities recorded at monitoring station No. 1 and No. 2 (see Figure 3.7-1) along the project boundary and Highway 21. These sound levels had durations on the order of less than one to several minutes. On the Lamefoot site itself, peak sound levels ranged between 53 and 72 dBA at monitoring station No. 6 in the employee parking lot, and between 51 and 80 dBA at station No. 7, about 100 feet from the mine portal. These peak sounds were also transient since they were caused by passing equipment or by short duration operation of a loader on the waste rock stockpiles.

Based on the data collected at the eight noise stations shown in Table 3.7-1, it is apparent that stations Nos. 1 and 3 represent primarily Highway 21 road noise, that stations Nos. 6 and 7 represent primarily noise from site activities, and that stations Nos. 4 and 5 represent noise data without the impact of either Highway 21 vehicular traffic or Lamefoot site activities. Accordingly, the 15-minute averages for each of the three noise environments are:

Lamefoot Site Activities	48.8 dBA
Highway 21 Traffic	43.1 dBA
No Site or Highway Noise	40.0 dBA

These representative noise levels are below the Washington State maximum permissible environmental noise levels.

3.8 SOILS AND RECLAMATION

3.8.1 General Conditions Prior to Exploration

3.8.1.1 Description of Soil Units

Principal landforms supporting soils in the Lamefoot project area include ridges, hilltops, and sideslopes of foothills to the north-south trending Kettle Range located east of the area, and stream and lake terrace surfaces and sideslopes of the north-south trending Curlew Lake, located immediately to the west. Elevations in the area range from 2,600 to 3,600 feet. Slopes range from nearly level to 50 percent. Eleven soil mapping units comprised of soils of six soil series and a colluvial land unit have been delineated within the area (USDA SCS 1979a):

CIE	Chesaw Stoney sandy loam, 0-45 percent slopes
Cu	Colluvial land (unstable talus slopes)
KoD	Koepke loam, 15-25 percent slopes
KoE	Koepke loam, 25-45 percent slopes
Mo	Mires loam, nearly level
MtB	Molcal silt loam, 0-8 percent slopes
MvB	Molson loam, 0-8 percent slopes
MvC	Molson loam, 8-15 percent slopes
MxE	Molson stoney loam, 25-40 percent slopes
MyE	Molson-Rock land, 15-50 percent slopes
VrE	Vallan-Rock land, 15-50 percent slopes

TABLE 3.7-1

RESULTS OF LAMEFOOT PROJECT NOISE SURVEY, MARCH 1993

	Morning Survey (3-16-93) Time Start: 8:16 am Time Stop: 12:42 pm		Midday Survey (3-19-93) Time Start: 10:17 am Time Stop: 3:35 pm		Afternoon Survey (3-18-93) Time Start: 2:40 pm Time Stop: 5:42 pm	
Monitoring Location Station	15 minute Average Sound Level	Peak Sound Level	15 minute Average Sound Level	Peak Sound Level	15 minute Average Sound Level	Peak Sound Level
1. Shoulder Hwy 21, S.W. Corner of Site	47.0	91.4	42.5	86.5	44.9	82.6
2. Entrance to Site on Hwy 21	41.0	84.2	43.2	85.8	49.4	87.0
3. Shoulder Hwy 21 away from Site	<40	87.4	40.1	89.6	44.1	79.8
4. N.W. Corner of Site	<40	57.0	<40	44.5	40.5	40.5
5. N.E. Corner of Site	<40	<40	<40	<40	<40	<40
6. Site Facilities Parking Lot	51.0	72.7	44.6	76.7	42.8	61.3
7. 100 ft. from Portal	50.6	61.7	52.7	87.8	51.3	65.0
8. Residential area, west side Corleus Lake	<40	63.0	40.3	59.6	42.6	63.6

Notes:
1) See Figure 3.7-1 for plotted locations of noise survey stations.
2) Values shown are in units of dBa.
3) Data collected using Amteck Mark-3 recording audio dosimeter.
4) 15 minute average represents a time-weighted average calculated by the dosimeter. Peak sound levels are the average sound level over a 1-second interval.

Source: Echo Bay 1993a

Parent materials for these soils are volcanic ash over glacial till or outwash. Areas not covered with glacial deposits such as Rock Land and some areas of Vallan soils support soils forming in weathering andesite.

Soils mapping for the project area is presented in Figure 3.8-1 (USDA SCS 1979a). The dominant Molson soils and similar Koepke soils occupy approximately 65 percent of the area. These upland soils of hilltops and hillsides are deep, well-drained loams to stoney loams with a predominately high water-holding capacity (A horizon) and moderate permeability. Runoff from these soils is moderate to rapid, and the erosion hazard for disturbed soils is moderate to very severe, with severity increasing as slope steepness increases. On rough ridges and hilltops, Molson soils include 20 to 45 percent Rock Land, which is a combination of rock outcrop and shallow soils (USDA SCS 1979a).

Soils and rock of the Vallan-Rock Land unit (20 percent of the project area) occupy the higher, steeper hills of the eastern portion. The unit consists of approximately 50 percent Vallan loam and 50 percent Rock land. Vallan soils are shallow, well-drained with a high water holding capacity (A and upper B horizons) and moderate permeability. Runoff is medium to very rapid, and the erosion hazard for disturbed lands is moderate to very severe, as influenced by slope steepness (USDA SCS 1979a).

Of the remaining 15 percent comprising the project area, colluvial deposits cover approximately 8 percent. The remaining 7 percent is occupied by deep to very deep, well-drained stoney sandy loam to loam soils forming on lowland terraces adjacent to Curlew Lake. Available water-holding capacity (A horizon) of these soils is low; permeabilities are mostly moderate. Runoff is slow to high and erosion hazard is slight to severe; higher rates for both runoff and erosion correspond to steeper slopes (USDA SCS 1979a).

3.8.1.2 Reclamation Potential of Project Area Soils

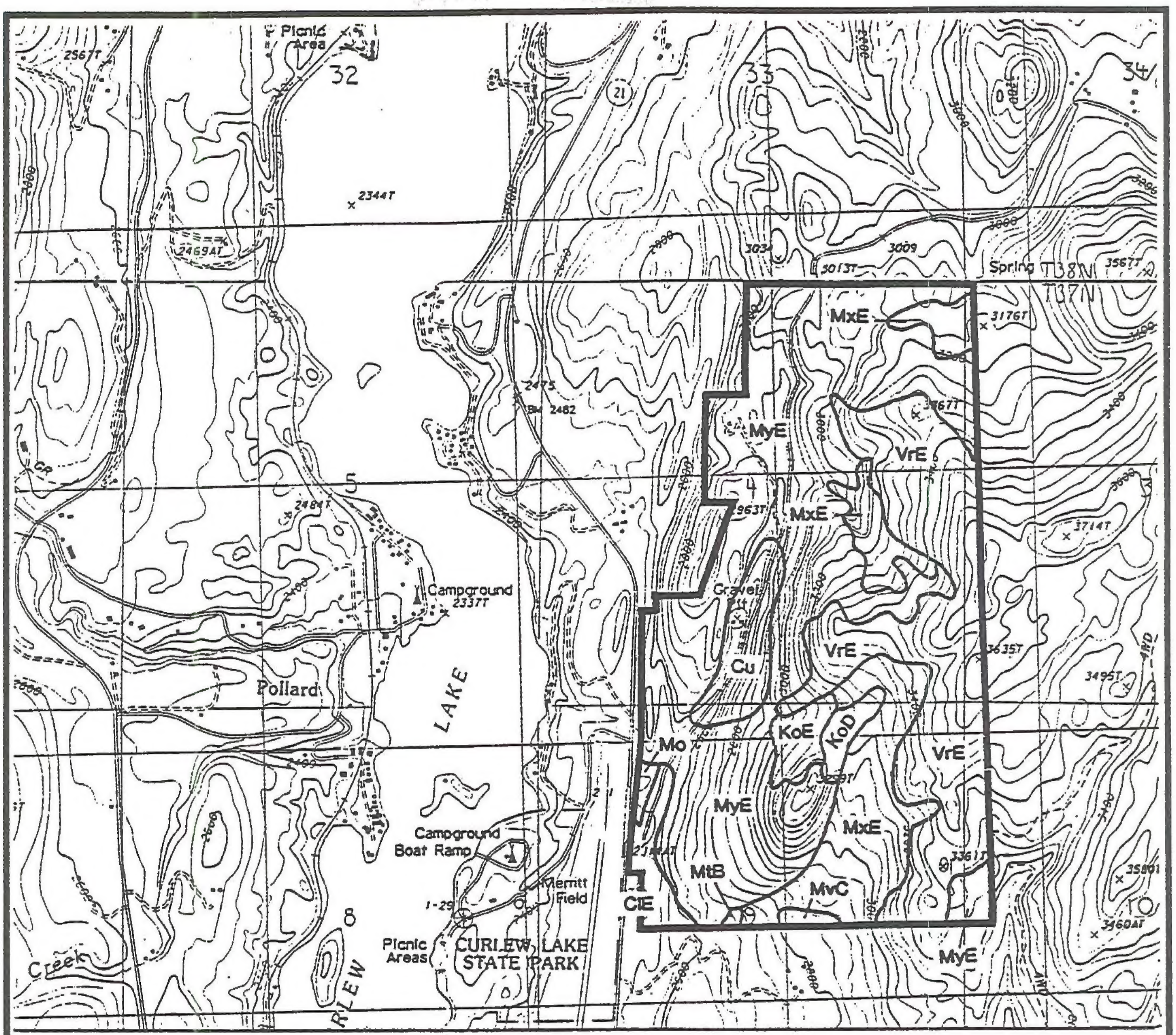
Soils of the project area represent a source of coversoil material for the reclamation of disturbed areas. Soil physical and chemical characteristics for the six soil series are presented in Table 3.8-1. Ratings of major soil profile horizons for suitability as coversoil material are also presented in Table 3.8-1. These ratings are based on suitability criteria presented in Table 3.8-2. Although percent organic matter content is not available for presentation in Table 3.8-1, organic matter content is projected to exceed 0.5 percent (good to fair suitability, Table 3.8-2) in A horizons of most of the soils in the project area. Content is expected to exceed 0.5 percent because most area soils are classified as having Mollic epipedons (surface horizons characterized by accumulations of organic matter). Based on the ratings and thicknesses of the horizons, a minimum of 12 inches of suitable (good to fair) soil material is present across the project area, with the exceptions of Colluvial Lands (Cu), Rock Lands within Molson (MyE) and Vallan (VrE) soil units, and previously disturbed lands.

3.8.2 Baseline Conditions

3.8.2.1 Exploration Activities

Exploration activities have resulted in the disturbance of both public and private lands under Notices of Operations. Approximately 4.4 acres of public (BLM) lands had been disturbed by the construction and operation of (a) facilities including exploratory drill sites and associated access roads and (b) a staging area for equipment storage, supply delivery, sample loading, and emergency medical evacuation (Table 3.8-3). During this same period of time, approximately 5.0 acres of disturbance occurred on private lands. The sources of these disturbances were also drill sites and access roads. Soils affected by disturbance on public and private lands are Molson (MxE, MyE) and Vallan (VrE) soils (Figure 3.8-1).

In July 1992, approval was given by the BLM for a exploration plan of operations which resulted in the disturbance of lands by additional drill site and access road construction and operation, and portal and associated surface facilities construction/operations. This additional drill site and access road construction



SOIL TYPES

CIE	Chesaw stony sandy loam, 0 to 45 percent slopes
Cu	Colluvial land
KoD	Koepke loam, 15 to 25 percent slopes
KoE	Koepke loam, 25 to 45 percent slopes
Mo	Miras loam
MtB	Molcal silt loam, 0 to 8 percent slopes
MvC	Molson loam, 8 to 15 percent slopes
MxE	Molson stony loam, 25 to 40 percent slopes
MyE	Molson rock land complex, 15 to 50 percent slopes
VrE	Vallan rock land complex, 15 to 50 percent slopes

CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

DRAWN | CHECKED J.C. | REVIEWED L.E.C.

TITLE
SOILS MAP OF LAMEFOOT PROJECT VICINITY

SOURCE: ECHO BAY, 1993a

DRAWN BDL	DATE APRIL 1993	JOB NO. 933-2614
CHECKED LEC	SCALE 1"=2000'	DWG NO./REV. NO.
REVIEWED SHM	FILE NO.	FIGURE NO. 3.8-1

TABLE 3.8-1

APPROXIMATE SOIL PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SOILS OF LAMEFOOT PROJECT AREA, WITH COVERSOIL RATING

Soil Series (Map Unit Symbol)	Percent Slopes	Major Horizons	Depth	Texture	Coarse Fragment	pH	Available Water-Rolm Capacity in/in	Permeability in/hr	Coversoil Suitability*
Chesaw (CIE)	0.45	A	0-12	sandy loam	<25	6.6-7.3	0.11-0.12	2.0-6.0	Good-Fair
		AC	12-18	gravelly loamy sand	40	6.6-7.3	0.11-0.12	6.0-20.0	Poor
		C	18-60	gravelly sand	40	6.6-7.3	0.02-0.03	6.0-20.0	Poor
Colluvial Land (Cu)	steep	--	--	--	>80	--	--	--	
Koepke (KoD, KoE)	15-45	A	0-34	loam to generally sandy loam	<20	6.6-7.3	0.14-0.18	0.6-2.0	Good-Fair
		B	34-41	gravely sandy loam	30	6.6-7.3	0.09-0.11	2.0-6.0	Poor
		C	41-60	gravelly sandy loam	30	8.5-9.0	0.03-0.05	6.0-20.0	Poor
Mines (Mo)	nearly level	A	0-14	loam	10	6.6-7.3	0.13-0.15	0.6-2.0	Good-Fair
		B	14-21	gravelly sandy loam	45	6.6-7.3	0.05-0.07	6.0-20.0	Poor
		C	21-60	gravelly sand	50	6.6-7.3	0.01-0.03	720.0	Poor
Mokal (MtB)	0-8	A	0-17	silt loam	5	7.9-8.4	0.19-0.21	0.2-0.6	Good-Fair
		C	17-60	gravelly silt loam	30	7.9-8.4	0.19-0.21	0.2-0.6	Poor
Molson (MvB, MvC, MxE, MyE)	0-8	A	0-18	loam	5	6.1-7.3	0.14-0.16	0.6-2.0	Good-Fair
		B	18-28	loam to generally loam	20	6.6-8.4	0.08-0.11	0.6-2.0	Good-Fair
		C	28-60	gravelly loam	40	6.1-8.4	0.08-0.11	0.6-2.0	Poor
Vallan (VrE)	15-50	A	0-2	loam	<5	6.1-7.3	0.12-0.14	0.6-2.0	Good-Fair
		B	2-16	loam	15	6.1-7.3	0.12-0.14	0.6-2.0	Good-Fair

Source: USDA SCS 1979a.

TABLE 3.8-2

SOIL MATERIAL SUITABILITY CRITERIA FOR SALVAGE AND REDISTRIBUTION AS COVERSOIL*

Soil Property	Good	Fair	Poor	Unsuitable
Texture	sandy loam loam silt loam	sandy clay loam silty clay loam clay loam	sand loamy sand sandy clay silty clay clay (<60%)	clay (>60%)
Coarse Fragment (% by volume)	0-10	10-20	20-35	>35
Organic Matter (%)	>1.5	0.5-1.5	<0.5	
pH	6.1-7.8	5.1-6.1 7.9-8.4	4.5-5.0 8.5-9.0	<4.5 >9.1
Available Water-Retention Capacity (in/in)	>0.16	0.08-0.16	<0.08	
Permeability (in/hr)	0.6-6.0	0.2-0.6	<0.2 or >6.0	

Source: USDA Forest Service. 1979b.

* Salinity and Sodium Adsorption Ratio (SAR) criteria; common suitability criteria are not included, as excessive salinity/alkalinity conditions are not characteristic of area soils; coversoil is soil material that can support the establishment of vegetation.

TABLE 3.8-3

AREAS OF DISTURBANCE, LAMEFOOT PROJECT

	Disturbance				
	Unpatented, BLM-administered Land		Patented, Private Lands		Total
Construction/Operations Actions	Acres[1]	Soils[2]	Acres	Soils	Acres
Approved Notices of Operations					
Drill Sites and Access Roads	4.4	Molson (MxE, MyE) Vannan (VrE)	5.0	Molson (MyE)	9.4
Approved Record of Decision					
Drill Sites and Access Roads	2.4	Molson (MxE, MyE) Vannan (VrE)	0.5	Molson (MyE) Vannan (VrE)	2.9
Portal #1 and Associated Facilities[3]	0		15.1	Molson (MyE) Mines (Mo) Chesaw (CIE)	15.1
Proposed Action (EIS)					
Rock Backfill Borrow Area[4]	0		18	Molson (MyE) Colluvial Land (Cu)	18
Connected Action					
Mill and Tailing Disposal Facilities	0		155	Chesaw (CIE) Mires (Mo) Republic (ReB, ReC)	155

[1] Source: Echo Bay 1993a.

[2] Source: USDA SCS 1979a.

[3] Associated Facilities: Shop; office parking lot, core shed, substation, pumphouse, staging area, topsoil stockpiles, ore stockpiles, settling pond, waste rock dumps, fuel storage container, explosives magazine, and drain field.

[4] Approximately 8 acres in the Rock Backfill Borrow Area has been previously disturbed.

resulted in the disturbance of approximately 2.4 acres of public land and 0.5 acres of private land (Table 3.8-3). Portal and associated surface facilities including shop and office yards, waste rock and ore storage piles, and coversoil storage piles disturbed approximately 15.1 acres of private land only. Soils affected by disturbance on public and private lands were again the steeper, upland Molson (MxE, MyE) and Vallan (VrE) soils (drill sites, access roads, and portal area and main waste rock pile), and the mostly level, lowland Chesaw (ClE) and Mires (Mo) soils (remaining surface facilities) (Figure 3.8-1).

3.8.2.2 Proposed Action

New disturbance of lands associated with the Proposed Action consists only of the development of the backfill rock borrow area on private lands (Figure 2-7). Maximum development of the backfill rock quarry would result in a disturbance of approximately 17-18 acres of hillside; approximately 8.0 acres have already been disturbed by previous quarry activities. Therefore, new disturbance would total approximately 10 acres. Soils likely to be affected by expansion of the rock quarry include Molson soils (MyE) and rocky, talus slopes (Colluvial Land, Cu). Of the 10 acres of proposed new disturbance, approximately 6.6 acres of Molson soils-Rock land and 3.4 acres of Colluvial Lands (Cu) would be disturbed. Colluvial Lands are not a source of suitable topsoil; however, where soils are present within the Molson-Rock land unit (MyE), a minimum of 12 inches and as much as 28 inches of suitable coversoil material is available for salvage. Erosion hazard for disturbed Molson soils would be moderate for slopes of 15 to 25 percent and severe for slopes in excess of 25 percent.

3.8.2.3 Mill and Tailings Disposal Facilities

Construction and operation of this facility has resulted in the disturbance of a total of 155 acres; approximately 30 acres have been disturbed by the mill facilities and 125 acres, have been disturbed by the tailings disposal impoundment. Soils affected on private land were the Chesaw (ClE), Mires (Mo), and Republic (ReB-Republic loam, 0-8 percent slopes and ReC-Republic loam, 8-15 percent slopes) soils. (Characteristics of the Chesaw and Mires soils were discussed previously in Sections 3.8.1.1 and 3.8.2.1.) Republic soils are well drained, nearly level to strongly sloping soils forming in volcanic ash and alluvium derived from glacial till. These soils occupy upland alluvial fans below high terraces occupied by Chesaw and Mires soils.

3.8.3 Current Status of Exploration and Mill Operations

Exploration activities continue at the Lamefoot Project; however, the maximum acreage of surface disturbance presented in Table 3.8-3 has been reached. Although exploration activities continue, activities will be confined to permitted areas of previous disturbance. Under BLM approvals, soils disturbance on approximately 6.8 acres and 20.6 acres has occurred on public (BLM) and private lands, respectively. Coversoil material salvaged ahead of drill site and access road construction totals 3,865 cubic yards (104,355 cubic feet) on public lands (Echo Bay 1993a, Appendix E, Table E1). Salvaged soils are stored as sidecast along roads and in small piles located in areas affected by surface disturbance. Coversoil material salvaged ahead of portal and associated supporting facilities construction totals an estimated 8,703 cubic yards (235,000 cubic feet). These salvaged soils are stored in three linear berms, which provide some visual shielding of the supporting facilities from vehicles traveling the adjacent highway (Figure 2-6). Results of laboratory analyses for four samples (Table 3.8-4) collected from separate locations on the coversoil storage berms indicate the soil materials represented by these samples can be rated as mostly good to fair coversoil materials (Table 3.8-2). Exceptions are the sand-texture of TS1B and the high percentage of coarse fragments present in all four samples. However, inspections of the berms indicated sand-textured soils are a minor constituent, and the bermed soils containing high percentages of coarse fragments are supporting a good cover of seeded grasses and are representative of the area's surface topsoils. A total of 8,847 cubic yards (238,865 cubic feet) is currently stored on site for use in reclamation.

TABLE 3.8-4

TEST RESULTS FOR STOCKPILE MATERIAL

Sample (Dry Weight)	TS1A	TS1B	TS2	TS3
Texture	Sandy Loam	Sand	Sandy Loam	Sandy Loam
SAR	0.49	0.39	0.45	0.65
Electrical Conductivity (μmhos/cm)	0.25	0.45	0.55	0.55
pH	8.2	8.1	6.6	7.0
Organic Matter (%)	1.1	1.3	1.9	1.2
Nitrate (ppm)	11.7	14.6	113.7	24.2
Phosphate (ppm)	4	6	6	3
Potassium (ppm)	88	114	176	112
Coarse Material (%)	58	54	43	57

Soil materials were salvaged ahead of construction of the mill and tailings disposal facilities. Total volume of coversoil for both facilities is 275,000 cubic yards, which would provide for a redistribution depth of a minimum of 1 foot over the entire disturbed mill and tailings disposal facilities.

3.9 AIR RESOURCES

3.9.1 Study Area

The objective of the air resources assessment is to identify and describe increases in air pollutant levels which could be affected by the proposed project. The study area includes those areas that receivers may travel through, recreate in, or reside in, where existing noise levels may be affected by the proposed action. This area would include Curlew Lake State Park and residences on the west side.

3.9.2 Baseline Air Resources Conditions

3.9.2.1 Climate

A description of the climate of the Lamefoot Project Area in Ferry County, Washington, was developed to determine the general climatological characteristics and dispersion potential of the area. The proposed project would not have an adverse impact on these conditions. The characteristics studied were temperature, precipitation, and evaporation. Climate data collected by the National Weather Service (NWS) indicate that no representative wind speed nor wind direction data are available for the area. NWS and site specific data representative of the project area vicinity are limited. The climate within the region of Washington encompassing the Project area is influenced by the topography, the prevailing westerly winds, the path of storm systems crossing the Pacific, the cold air masses moving southward from the Arctic region, and the distance and direction from the ocean.

Annual Precipitation

The annual precipitation near the project site ranges from 12 to 18 inches in the lower valleys to 30 inches or more at higher elevations. The average precipitation in Republic is 15.4 inches per year (State of Washington DOE 1988). Winter season snowfall in the valleys varies from 40 to 80 inches. Both rainfall and snowfall increase along the slopes of the mountains. Snow can be expected in the higher elevations in October and in the lower valleys by the last of November. In the lower elevations, snow reaches a depth of 15 to 30 inches and remains on the ground most of the time from the first of December until March. Annual Class A pan evaporation is estimated to be 25 to 35 inches at the site, while the free-water surface evaporation occurs at a rate of approximately 20 inches per year (State of Washington DOE 1988).

Temperature Ranges

Cold continental air moving southward through Canada will occasionally cross the higher mountains and follow the north-south valleys into the Columbia Basin. On clear, calm winter nights, the loss of heat by radiation from a snow cover produces ideal conditions for low temperatures. Temperatures ranges include:

- In January, the average maximum temperatures is near 30°F and the minimum temperature is 15°F.
    - Minimum temperatures from -10°F to -20°F are recorded almost every winter.
    - Temperatures ranging from -25°F to -42°F have been recorded in the colder valleys.

- In July, the average maximum temperature is 85°F to 90°F and the minimum temperature is 45°F to 50°F.
  - Maximum temperatures reach 100°F on a few afternoons each summer.
  - Temperatures between 105°F to 110°F have been recorded.

Temperature extremes in Ferry County between 1960 and 1978 were -38°F and 102°F (State of Washington DOE 1988). The average annual temperature in Ferry County is 42.6°F. The average date of the last freezing temperature in the spring is the last of April in the warmer valleys and the first of June in the colder localities. In the fall, the first freezing temperature can be expected in the colder valleys by the first of September and before mid-October in the warmer areas.

Dispersion Meteorology

The project area is located in a valley which drains north to the Kettle River. According to Holzworth (1972), annual average mixing heights (depth of inversions) for this area are about 400 meters, while annual average afternoon mixing heights are about 1,400 meters. Stable, night-time drainage flows may be possible down valley, and could trap combustion sources such as wood-burning stove emissions in populated areas. However, these potential, but undocumented local flows, and any wintertime inversion would not necessarily exacerbate air pollution concentrations from the ground level, fugitive dust emission sources associated with mining activities.

3.9.2.2 Air Quality

Very little air monitoring data have been collected by federal, state, or county agencies in the vicinity of the Lamefoot Project Area. The air quality of the region surrounding and including the Lamefoot Project Study area is generally good. The DOE has classified the area as in attainment for all criteria pollutants, which means ambient concentrations of criteria pollutants do not exceed their respective air quality standards. Table 3.9-1 provides the ambient air quality standards for the criteria pollutants. Irrespirable dust (PM_{10}) is the only pollutant that the state monitors in the northern Washington Air Quality Control Region, which includes the study area. Other pollutants do not exist in sufficient quantities to warrant sampling by the state. The maximum 24-hour PM_{10} concentration measured in the Northern Washington Intrastate Air Quality Control Region in 1992 was 73 $\mu g/m^3$. The annual PM_{10} concentration for 1992 was 22 $\mu g/m^3$. Air permits for the various projects associated with this project require only calculation of annual emission rates. No impact analyses which estimate air pollutant concentrations have been conducted. Thus, these emissions rates can not be compared to the ambient air quality concentration standards.

3.9.3 Exploration Activities

Dust is the only substantial air quality concern generated by the Lamefoot Exploration Activities. Dust has been effectively controlled throughout the implementation of various common dust control measures (such as watering of haul roads).

3.10 RECREATION

3.10.1 Study Area

The study area for recreation resources includes the Lamefoot Project site and recreation areas within the Curlew Lake Valley and the Colville National Forest that may be affected, either directly or indirectly, by the proposed action.

TABLE 3.9-1

SUMMARY OF AMBIENT AIR QUALITY STANDARDS FOR CRITERIA POLLUTANTS
(micrograms per cubic meter, $\mu g/m^3$)

Pollutant[1]	Averaging Period	Federal Standards[2] Primary	Federal Standards[2] Secondary
Particulate Matter (PM_{10})	Annual	50	NA
	24-Hour	150	NA
Total Suspended Particulates (TSP)	Annual	NA	NA
	24-Hour	NA	NA
Sulfur Dioxide (SO_2)	Annual	80	NA
	24-Hour	365	NA
	3-Hour	1,300	NA
Carbon Monoxide (CO)	8-Hour	10,000	10,000
	1-Hour	40,000	40,000
Nitrogen Dioxide (NO_2)	Annual	100	NA
Lead (Pb)	3-month	1.5	1.5
Ozone (O_3)	1-Hour	235	NA

[1] Gaseous concentrations are corrected to a reference temperature of 25°C and to a reference pressure of 760 millimeters of mercury.

[2] All maximum values are not to be exceeded more than once per year and ozone standard is not to be exceeded during more than one day per year.

NA Not applicable
Source: U.S. Congress (1977)

3.10.2 Baseline Conditions (Pre-1992)

The following baseline description of recreation resources is taken from the 1988 Kettle River Project FEIS and the 1992 Kettle River Key Project Expansion FEIS.

The Colville National Forest, located to the east of the Lamefoot site, provides for dispersed recreation activities such as hunting, fishing, camping, off-road vehicle use, cross-country skiing and snowmobiling. In the area of the Forest within the vicinity of the Lamefoot Project, hunting is the primary recreational activity, especially the fall deer hunt. Dispersed recreation sites have been identified at Lower Lambert Creek, the Herron Creek switchbacks, the Herron Creek campground, and Mires Creek Camp. Further east, the Forest provides important backcountry use areas. The Lambert Creek Road provides access to a feeder trail which leads to the Kettle Crest Trail, a National Scenic Trail that runs from the Canadian border to the Colville Indian Reservation. The North-Fork Sanpoil River and Bracken Creek roads (near the Key Mill) also provide access to feeder trails to the Kettle Crest Trail, but use is not as great as the Lambert Creek Road access.

Curlew Lake State Park is located directly across State Highway 21 from the Lamefoot project. Facilities at the park include campgrounds, picnic areas and a boat launch. Peak use period is June through September. Private campgrounds are also found along the lake.

3.10.3 Exploration Activities (1992-1993)

As described under the baseline condition section, the Colville National Forest provides for various recreation activities. Hunting is the primary recreation use of Forest lands surrounding the Lamefoot or related project facilities. The general description of Forest recreation has not changed from the baseline condition. State Highway 20, which runs through the Colville National Forest, is a designated National Scenic Byway, from the junction of State Highway 395 on the east to the junction with State Highway 21 on the west.

Curlew Lake State Park is the major developed public recreation facility within the study area. Peak use periods are from June through September. Visitor use data from Curlew Lake State Park show the following number of visitors from 1988 through 1992:

Year	Total Visitors
1988	78,315
1989	71,741
1990	77,874
1991	97,726
1992	81,407

Visitor use data are based on vehicle counts at the park entrance, and include a multiplier for average number of people per vehicle (3.5 people/vehicle). Park management attributes the yearly variance in number of visitors to weather conditions, the quality of fishing, and economic factors. According to the Park (Johnson 1993), exploration activities at the Lamefoot Mine have not significantly affected the quality or the amount of use of the Park. Comments from the public regarding the ongoing exploration activities at the Lamefoot site have been few, and have mostly been concerned with noise coming from the mine at night.

There are several private resorts on Curlew Lake, with a total of approximately 65 cabins. They include Tiffanys Resort, Black Beach Resort, Fisherman's Cove Resort, and Pine Point Resort. Activities associated with the resorts include camping, fishing, boating and water skiing. A new resort is being planned at the north end of the lake which will increase the recreational use in the area. Many private residences also add to the recreational use of the lake and surrounding area.

3.11 SOCIOECONOMICS

3.11.1 Study Area

The socioeconomic study area for the Lamefoot project includes the portion of northwestern Ferry County, Washington that would experience social and economic impacts of the proposed project. The socioeconomic study area is bordered by the Okanogan - Ferry County line on the west, the Kettle Range on the east, and the communities of Republic on the south and Curlew on the north respectively. Figure 4.15-1 provides a map depicting the socioeconomic study area.

This section describes socioeconomic conditions within Ferry County, focusing on elements likely to be affected by the proposed Lamefoot Project. Socioeconomic factors described include population, employment, earnings, indirect economic activity stimulated by the mining industry, and tax revenue generation.

3.11.2 Baseline Conditions Prior to 1992

3.11.2.1 Population

Population in Ferry County grew from 5,811 in 1980 to 6,295 in 1990, an increase of 8 percent over the ten-year period (U.S. Department of Commerce, Bureau of the Census 1991). Of the total 1990 Ferry County population, 85 percent lived in unincorporated portions of the county and 15 percent lived in the incorporated town of Republic (Trico Economic Development District 1990; Planning Information Corporation 1991). Tables 3.11-1 and 3.11-2 provide a breakdown of Ferry County's population by age and ethnicity.

3.11.2.2 Employment and Earnings

Ferry County experienced impressive growth in total employment and earnings from 1986 to 1991. Total employment in Ferry County in 1986 was 1,383 jobs. This figure rose steadily to 1,880 by 1991, an increase of 36 percent for the five-year period. Moreover, total earnings rose by 96 percent during the same period. The distribution of employment among various sectors of the economy also changed during that period. Employment by the mining industry more than tripled, with considerable growth in the retail, service, and government sectors. Conversely, the manufacturing (forest products) and agricultural sectors declined over that time period (City of Republic 1992). Tables 3.11-3 and 3.11-4 provide descriptions of employment and earnings in Ferry County from 1986 to 1991 for various economic sectors.

In general, the employment and earnings situation in Ferry County between 1986 and 1991 can be summarized as follows. In terms of numbers of jobs, the government and mining sectors were the largest employers in 1991. Large employment gains during the period occurred in the services (41 jobs) and retail (60 jobs) sectors. Moreover, the mining industry grew by 247 jobs during this period, indirectly producing much of this service and retail sector growth (City of Republic 1992). The largest employment losses came in the manufacturing sector, which declined by 79 jobs. This decline was related to reduction in manufacturing of wood products.

In terms of total earnings, the mining and government sectors produced the most income in 1991, with manufacturing as the third highest sector. In terms of growth in total earnings, the mining and government sectors increased the most and the manufacturing sector declined the most. The most highly-paid jobs in Ferry County in both 1985 and 1991 were in the mining sector. Manufacturing jobs were the second highest paying jobs in both 1986 and 1991, but suffered the smallest growth in wages during the period.

TABLE 3.11-1

AGE DISTRIBUTION IN FERRY COUNTY, WASHINGTON

Age	Number
0 - 9	1,058
10 - 19	1,150
20 - 29	674
30 - 39	1,049
40 - 49	876
50 - 59	575
60 - 69	494
70 - 79	304
80+	115
Total	6,295

Source: Washington Office of Financial Management 1991.

TABLE 3.11-2

1991 POPULATION DISTRIBUTION BY ETHNIC GROUP

Ethnic Group	Number	Percentage
White	5,084	79.7%
Native American	1,131	17.7%
Black	20	0.3%
Hispanic	85	1.3%
Asian	24	0.4%
Other	36	0.6%
	6,380	100.0%

Source: Washington Office of Financial Management 1991.

TABLE 3.11-3

FERRY COUNTY EMPLOYMENT BY SECTOR, 1986 AND 1991

Sector	Employment					
	Number of Jobs		Percent of County Employment		Employer Rank	
	1986	1991	1986	1991	1986	1991
Government	436	626	31.5	33.3	1	1
Service Industry	193	234	14.0	12.5	4	4
Retail	206	266	14.9	14.1	3	3
Manufacturing	266	187	19.2	10.0	2	5
Farms & Agriculture	123	108	8.9	5.7	5	6
Mining	112	359	8.1	19.1	6	2
Other	47	100	3.4	5.3	7	7
Total	1,383	1,880	100	100	--	--

Source: City of Republic 1992.

TABLE 3.11-4

FERRY COUNTY EARNINGS BY ECONOMIC SECTOR, 1986 AND 1991

Sector	Earnings					
	Average Salaries		Percent of County Earnings		Rank - Highest Earnings	
	1986	1991	1986	1991	1986	1991
Government	16,526	19,859	34.6	30.5	3	3
Service Industry	10,824	14,490	10.0	8.3	5	5
Retail	6,171	8,473	6.1	5.5	7	7
Manufacturing	20,946	23,394	26.8	10.7	2	2
Farms & Agriculture	7,784	11,281	4.6	3.0	6	6
Mining	28,571	43,012	15.3	37.9	1	1
Other	11,169	16,569	2.6	4.1	4	4
Total	15,224	22,276	100	100	--	--

Source: City of Republic 1992.

Indirect Economic Activity Stimulated by the Mining Industry

Economic activities that are generated by Ferry County's basic industries — such as mining, manufacturing, and agriculture — stimulate indirect economic activity in other economic sectors, such as the retail and service industries. With respect to the mining industry, this indirect economic activity arises out of purchases of inputs (e.g., equipment and electric power) by mining companies and mining industry employees, which spend their dollars on goods and services offered by local area businesses. This indirect economic activity can be measured and expressed in terms of job creation as the "multiplier effect" of mining employment. For Ferry County, the multiplier effect of mining employment is estimated to be 1.5 (City of Republic 1993a). That is, for every mining industry job that exists in Ferry County, roughly 1.5 jobs have been created in other economic sectors. As a result, the 359 mining jobs that existed in 1991 were indirectly responsible for roughly 538 jobs in Ferry County in other economic sectors, with associated earnings of approximately $3,400,000.

Conversely, loss of mining and other basic industry jobs results in an indirect loss of retail and service sector jobs, based on the same multiplier effect. The substantial growth of mining industry employment in the study area from 1986 to 1991 has helped to offset direct and indirect job losses associated with the decline of the manufacturing and agricultural sectors.

3.11.3 Baseline Conditions During Exploration Activities (1992-1993)

3.11.3.1 Population

From 1990 to 1993, population in Ferry County grew by 6.4 percent to 6,700 residents (City of Republic 1993b). Age distribution and ethnic composition remained generally the same as they were in 1991, however.

3.11.3.2 Employment and Earnings

During 1992 and 1993, mining continued to be the highest paying work sector, although the number of workers employed dropped by approximately 50 positions (Echo Bay 1993d). This loss of mining jobs resulted in a direct loss of approximately $2,150,000 in earnings. The following is a discussion of the nature of mining job losses.

One of the main causes of mining employment loss was Echo Bay's closure of the Overlook mine in September 1992, due to lack of profitability. As a result, 68 mine workers were laid off. In addition, mining at the Key East and West mines ended in October, 1993, when surface minable ore reserves were exhausted. Closure of the Key mines resulted in the reassignment of 35 contract workers to operations outside of the study area. In total, 103 mining jobs have been lost as a result of closures of Echo Bay mining operations over the last two years (Echo Bay 1993a).

Similarly, in 1992-1993 two of Ferry County's other major mining and forest products employers (Hecla and Vaagen Bros., respectively) also reduced their workforces. These reductions, combined with Echo Bay's staff reductions and contractor terminations, have resulted in an increase in unemployment in Ferry County from 10.1 percent in January of 1992 to approximately 11.5 percent in 1993.

Despite mining employment losses due to closure of three Echo Bay mines operations, new positions have been created by Echo Bay during the same time period. Specifically, the Lamefoot exploration program has created 35 new jobs. In addition, expansion of work of the Key Mill tailings pond in summer, 1993, created another 30 contract positions. Thus, although 103 mining jobs were lost in 1992-1993, roughly 65 were created. Thus, the net loss of mining jobs was 38 (Echo Bay 1993a).

3.11.3.3 Tax Revenue Generation

The mining industry in Ferry County generates considerable tax revenue for the state and local governments. Direct tax payments include payroll, sales, ad valorem and business and occupation taxes. In addition to these direct payments, the mining industry generates indirect tax revenue through income, ad valorem, and sales taxes paid by mining company employees and through other indirect economic activities stimulated by the mining industry. Echo Bay's employment of workers at its various mining and exploration properties, Key Mill, and administrative office generated approximately $950,000 in payroll taxes in 1992 (Echo Bay 1993a).

The State of Washington imposes a sales/use tax of 6.5 percent on the sale of all goods. Local governments impose additional sales and use taxes, varying in amount from 0.5 percent to 1.7 percent. The local sales and use tax is consistent throughout a county, whether it is imposed within or without a municipality. In Ferry County, for instance, a 1 percent sales and use tax is levied. If a purchase is made in Republic, the 1 percent accrues to the city; if a purchase is made in a rural portion of Ferry County, the 1 percent accrues to the county (Vickers 1991). In 1992, the Kettle River operations paid a total of $1.7 million in sales tax.

Property is assessed at 100 percent of its fair market value, based on comparable sales. Most property is appraised every four years, but gold mines are appraised annually. The value of a gold mine includes tangible and intangible worth, including its present worth, the price of gold, the probability to increase reserves, as well as the value of equipment (Sweetman 1991). Total fiscal 1992 property tax revenues in Ferry County are predicted to be somewhat over $2 million for all taxing jurisdictions (Ferry County 1991). Of that amount, Echo Bay paid approximately $630,000.

The State imposes no minerals severance tax, but does exact a small tax on gross sales or income. This business and occupation tax includes an extraction class, which applies to logging and mineral extraction including gold mines. The current rate is 0.484 percent of the total gross receipts or $4.84 per thousand of gross income (Lee 1991; Sweetman 1991). In 1993, the Lamefoot Project will pay an estimated $3,753 in business and occupation taxes of the $160,000 paid for Kettle River operations as a whole.

3.11.3.4 Social Setting

The social setting in Ferry County is dominated by participants in the four or five economic sectors previously mentioned: recreation, government, mining, forest products, and agriculture. Services of a secondary and tertiary nature are presented for the primary sectors noted above, mostly in the towns of Republic and Curlew, and at the State Park (see Section 3.10). Social groups are likely focused on these sections with some portion being concerned with recreation or permanent homes within the vicinity of the project (Tables 3.11-1 and 3.11-2).

3.12 CULTURAL RESOURCES

3.12.1 Study Area

The scope of the EISS evaluation is the Lamefoot Expansion area. The scope of the evaluation does not include other Echo Bay mines or mill sites. A discussion of the cultural resources located during survey of the other resource development projects is included in Section 4.15, Cumulative Impacts.

3.12.2 Baseline Conditions

The study area has been surveyed for cultural resources (Holstine 1992a, 1992b). Figure 3.12-1 depicts the area surveyed by Holstine (1992a and 1992b) and Bailey (1993) at the Lamefoot Mine relative to the proposed and existing facilities. All areas were surveyed prior to drilling and construction activities except the Waste Storage Stockpile #2. The two Holstine reports are included as Appendix C in Lamefoot Drilling Program Environmental Assessment. Holstine (1992a and 1992b) noted five historic mining prospects on land managed by the BLM and an adit and air compressor foundations on private land. None of these resources were considered eligible for the National Register, and the SHPO concurred with this decision (Griffith 1992).

The Lamefoot claims were patented in 1899 and transferred from public domain to Jacob Goetz and Co. Jacob Goetz and his partner, Harry Baer, had made fortunes on mines in Idaho and also ran a well-known hotel and gambling establishment in Spokane (the Coeur d'Alene Hotel). Due to the very limited historic development of the Lamefoot claims, it is unlikely this property contributed substantially to their fortunes (Holstine 1992b).

No cultural resources locations attributable to Native American activities were located in the project area. "Ethnographically, the project area lies within the traditional territories of at least two Interior Salish groups; the Sanpoil-Nespelems and the Lakes Indians (Ray 1933; 1936)" (Holstine 1992a). The nearest reported village sites were located several miles north and south of the project area.
The project area was at one time part of the Colville Indian Reservation, and was opened for mining in 1896. Although there were numerous claims patented, the Belcher Mine on Cooke Mountain (northeast of the Key mill and tailings) appears to have been the only productive mine in the general mining district (Holstine 1992a).

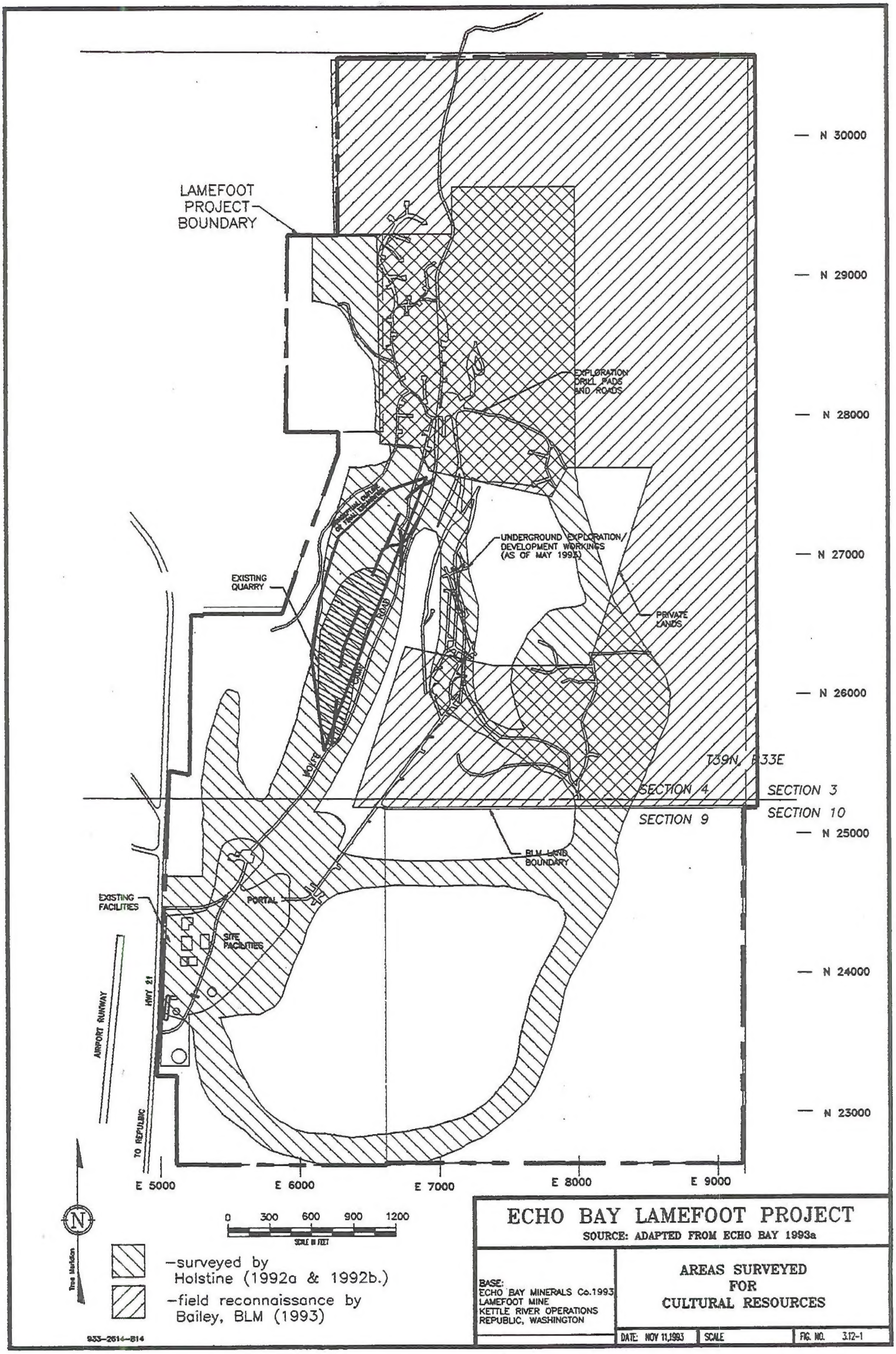
The Colville Confederated Tribes were consulted concerning resources of concern to their tribes (Miller 1992). There were no sites or localities of concern identified within the project area (drilling and mine development).

Portions of the permit area on federal land were the subject of a field reconnaissance by BLM archaeologist R. Bailey in 1993. Portions of this reconnaissance overlap areas surveyed by Holstine (1992a; and see Figure 3.12-1). No determinations of eligibility were made for the three habitation sites and 15 prospect pits located by this field reconnaissance outside the proposed project impact area.

3.13 VEGETATION

3.13.1 Study Area

The overall vegetation study area vicinity is shown in Figure 3.13-1, and includes the Lamefoot site, as well as the K-2 exploration area, the existing Key Mill, and the Overlook, Key West, and Key East mines. This area lies within the Okanogan Highland physiographic province, which includes mountainous terrain between the Okanogan River to the west and the Selkirk Mountains to the east. This large area is vegetated with a complex mosaic of closed to open-canopy forest dominated by Douglas fir with some ponderosa pine, interspersed with areas of grass-shrub with scattered or no trees. Deciduous forest and shrubland exists along drainage courses and in isolated wetlands in depressional areas. Logging is ongoing on both private and public lands, and forest vegetation ranges in age from recently logged areas to older conifer forests that have never been harvested. The vegetation of the vicinity of the Key East and West pits is described in the EIS on that project (USFS 1992). It consists of recently logged areas, stream corridors draining to the north and south; conifer forest dominated by Douglas fir on north-, east-, and west-facing slopes; native grasslands on south-facing slopes, and transitional areas of scattered trees dominated by ponderosa pine in between forests and grasslands. The Overlook Mine portal and Key Mill are located on south-facing slopes, which



▧ —surveyed by Holstine (1992a & 1992b.)

▨ —field reconnaissance by Bailey, BLM (1993)

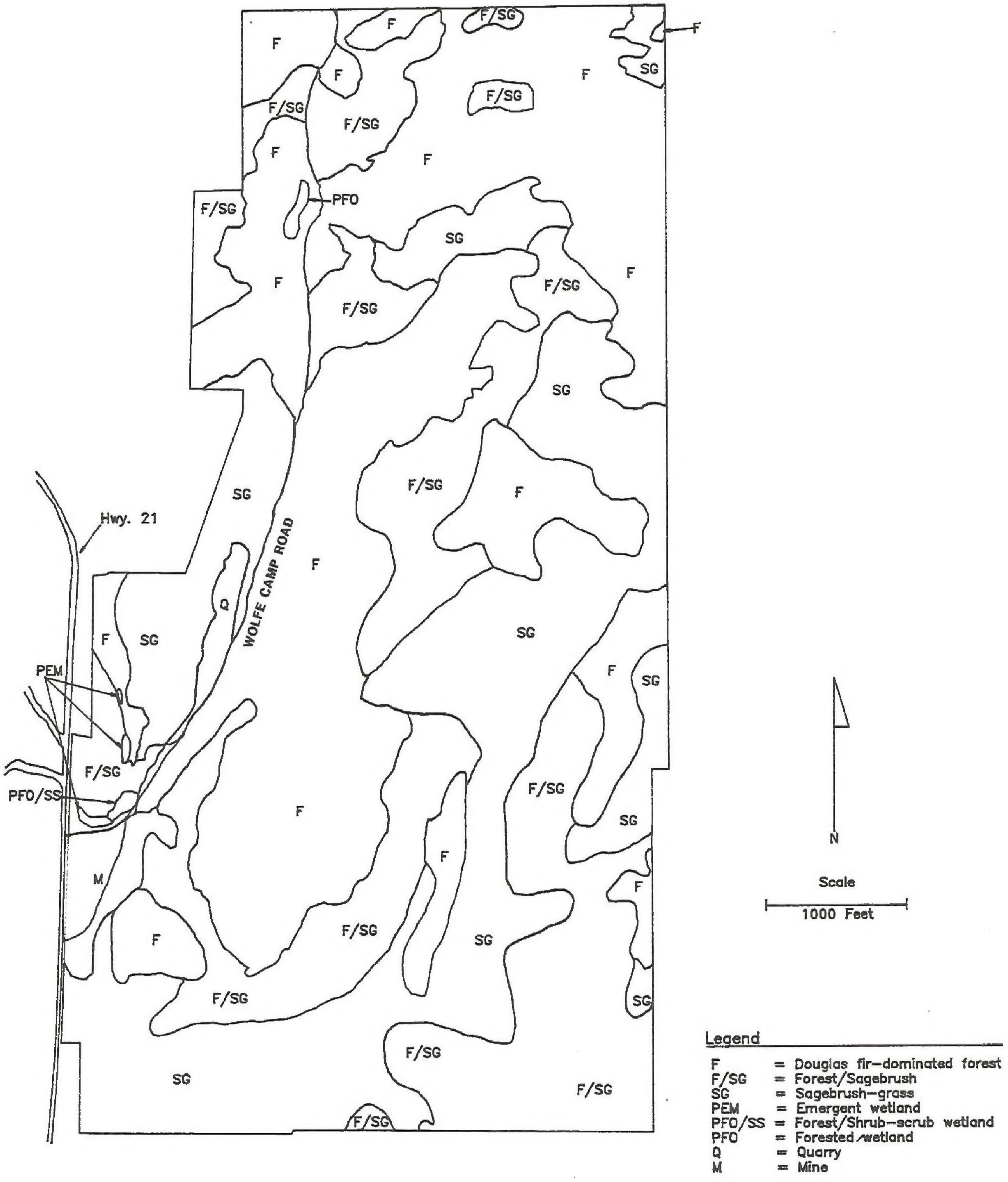
ECHO BAY LAMEFOOT PROJECT

SOURCE: ADAPTED FROM ECHO BAY 1993a

BASE:
ECHO BAY MINERALS Co.1993
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

AREAS SURVEYED FOR CULTURAL RESOURCES

DATE: NOV 11,1993 | SCALE | FIG. NO. 3.12-1



Legend

F = Douglas fir–dominated forest
F/SG = Forest/Sagebrush
SG = Sagebrush–grass
PEM = Emergent wetland
PFO/SS = Forest/Shrub–scrub wetland
PFO = Forested wetland
Q = Quarry
M = Mine

ECHO BAY LAMEFOOT PROJECT

ADAPTED FROM ECHO BAY, 199

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

MAP SHOWING VEGETATION TYPES IN PROJECT AREA

DATE NOV 19,93 | SCALE | FIG. NO. 3.13-1

FILE: 3-1-4

have adjacent grassland, transitional, and forest habitats, including a deciduous riparian strip along the stream draining from the Overlook Mine portal area.

3.13.2 Baseline Conditions Prior to June 1992

Methods

This description of the vegetation of the Lamefoot study area is derived from the EA on the Lamefoot Project (Golder 1992c), a botanical survey of the study area (Mastrogiuseppe Environmental Consultants 1991), the National Wetland Inventory Map (Republic NW Quadrangle, USFWS 1987), and the Ferry County Soil Survey (USDA SCS 1979a).

Disturbance

At the time of the field survey in October 1991 (Golder 1992c), areas disturbed by mining exploration included active and inactive exploration drilling areas and access roads. The disturbance was most evident on the steep west-facing slopes east of Wolfe Camp Road. Other existing disturbed areas included the gravel mine along Wolfe Camp Road and an area heavily grazed by livestock in the vicinity of the core shed. Areas which were not disturbed were in generally good condition. Figure 3.13-1 includes several disturbed areas. A quarry (Q in Figure 3.13-1) is located along the west side of Wolfe Camp Road. The area currently shown as mine (M) was not present prior to June of 1992, and supported a combination of sage-grass and forest vegetation (see below). Wolfe Camp Road is also shown on Figure 3.13-1; this is also a disturbed area.

Vegetation

The Lamefoot area is primarily forested, and most of it supports a Douglas fir/ninebark community. Other communities present in smaller, scattered patches include ponderosa pine/Douglas fir forest, shrub/grass communities, aspen and/or cottonwood groves, and wetlands. Mastrogiuseppe Environmental Consultants (1991) describe the vegetation in detail. A map showing the general vegetation types in the area, based on aerial photography taken in April 1993, is shown on Figure 3.13-1. The upland vegetation types distinguished from the aerial photography included closed to open canopy forest (F on Figure 3.13-1), areas transitional between forest and shrub-grass with scattered trees (F/SG), and shrub-grass (SG) with few or no trees.

A Douglas fir/ninebark forest (F in Figure 3.13-1) with a closed canopy is the dominant community on the site. Snowberry and ponderosa pine are also fairly common throughout. The canopy is more open, and snowberry and ponderosa pine are more common on drier microsites, such as rocky areas and south and west-facing slopes. These areas are included in the F/SG vegetation type in Figure 3.13-1.

Bunchgrasses such as bluebunch wheatgrass and Idaho fescue dominate dry open areas. Kentucky bluegrass communities occur where there are moist openings. Cheatgrass predominates in highly disturbed areas. A big sagebrush/bluebunch wheatgrass habitat occurs along upper ridges. This vegetation type is mapped as SG in Figure 3.13-1.

There are several moist swales where quaking aspen and black cottonwood predominate. In these areas, common understory shrubs include oceanspray, twinflower, Columbia clematis, and black hawthorn. These areas were not classifiable as wetlands based on the vegetation, and are not shown on the vegetation map because they were not obvious in a leaf-off condition, but they are located on the west side of Wolfe Camp Road.

Wetlands

Wetlands are regulated by the U.S. Army Corps of Engineers with advisory input from the Washington Department of Ecology. The regulatory definition of wetlands used by EPA and the Corps of Engineers (Corps) for administering the Section 404 permit program is: "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." (33 CFR 328.3). Wetland values recognized by state and federal regulatory agencies include wildlife habitat (many listed species are dependent on wetlands for some part of their life cycles), flood protection, water quality improvement through trapping of pollutants and sediments, scenic and aesthetic diversity. Wetlands under the jurisdiction of the Corps cannot be filled without a permit.

The areas identified as wetlands during the field survey were those that appeared to support a prevalence of plants adapted for life in saturated soil, based on the list of hydrophytic plants provided by the USFWS (Reed 1988). A formal wetland delineation study was not conducted in these areas. Several small wetlands exist along the main drainage corridor that is oriented north-south and parallel to Wolfe Camp Road. The canopy is predominately quaking aspen, with willows, redosier dogwood, and a variety of grasses, sedges, and forbs that are typically associated with wetlands. Wetland locations are shown in Figure 3.13-1.

The largest wetland complex is located at the southern end of the site below the quarry area, and consists of a grazed area with a series of ponds and a drainage that passes to the west of the core shed before disappearing into the ground east of Highway 21. A small spring also originates on the east side of Wolfe Camp Road, about 500 feet northeast of the core shed. The water sources for this lower wetland are the ponds in the narrow valley above, and the spring. The lower part of this wetland includes deciduous vegetation along a small stream fed by the spring on Wolfe Camp road, and pasture grazed to a height of one or two inches near Highway 21. This area is shown on Figure 3.13-1 as PEM, a palustrine emergent wetland and PFO/SS, palustrine forested and shrub-scrub complex, using classifications from the National Wetlands Inventory (Cowardin et al. 1977).

The upper wetland area adjacent to Wolfe Camp Road is also mapped as PFO, palustrine forested wetland. Two seasonal ponds occupy the bottom of a drainage swale west of Wolfe Camp Road. The Lamefoot exploration drilling program was modified in 1992 to avoid this wetland area (Golder 1992c). This area is shown as PFO on Figure 3.13.1.

Special Status Species

The primary goal of the botanical survey by Mastrogiuseppe Environmental Consultants (1991) was to search for and identify any rare, threatened, or endangered plants in the vicinity. According to the EA (Golder 1992c), there were no federally listed or candidate plant species known to occur in Ferry County. According to the Washington Natural Heritage Program (1990a), there were several species of concern to the State of Washington that occurred in Ferry County. One species of concern which had not been previously recorded in Ferry County, many-headed sedge (*Carex sychnocephala*), was found in the study area. A small population of this species is present on the western edge of the larger pond-wetland near the south end of the site. This small population was located a few yards north of the core shed, and was heavily impacted by grazing and trampling by livestock pastured in this area.

Timber and Range Resources

Some limited logging has occurred in this area in the past, but the terrain and soil susceptibility to erosion reduces the potential for much timber harvest. Grazing also occurred prior to June 1992, but was concentrated in the flatter, moister areas within the site, particularly in the lower wetland areas now mapped as PEM, and in the moist drainage swale above the quarry area.

3.13.3 Baseline Conditions After Lamefoot Exploration (after June 1992)

Methods

Changes occurring after June 1992 were identified through an on-site reconnaissance in October 1993, and examination of aerial photos of the site from April 1993. Wetland areas identified in the EA (Golder 1992c) were visited, and general notes on conditions were recorded.

Disturbance

Additional areas were disturbed by exploration after June 1992. The remainder of the area was still relatively undisturbed and in good condition after June 1992. The exploration roads and pads that were located to the west of Wolfe Camp Road had re-established vegetative cover and were difficult to identify at the time of the October 1993 field reconnaissance. Exploration roads east of Wolfe Camp Road were still evident on the steep slope. Exploration activities also eventually covered the 27-acre area shown as mine (M) on Figure 3.13-1.

Vegetation

Between October 1991 and October 1993, livestock were removed from the lower wetland/pasture area (mapped as SG, and including PEM and PFO/SS) and the vegetation is in the process of recovering.

The vegetation in areas undisturbed by mining is in the process of recovering from the former livestock grazing. Percent ground cover and vegetation height has increased to nearly 100 percent and 3 feet in height in the upland portions of the lower former pasture. More suitable improvements are evident above the quarry in terms of slight increases in cover and height. The wet summer of 1993 also undoubtedly contributed to these improvements.

Wetlands

Owing to removal of livestock and the moist conditions during the summer of 1993, the grasses in the open pasture area that were one or two inches tall in October 1991 were over four feet tall along the channel and beyond, where no surface flow was evident in October 1993. Young willows over 6 feet in height are already present in the area of this former pasture that is mapped as PEM, and this area can be expected to develop shrub-scrub and ultimately forest vegetation, as long as livestock are excluded.

Special Status Species

Removal of livestock from the lower wetland area has benefitted the one plant species of concern known to occur on the Lamefoot area, many-headed sedge. The effects of grazing and trampling have been eliminated, and this population of plants has benefitted as a result.

Forest and Range Resources

Forest resources have decreased slightly as a result of the removal associated with the exploration that occurred after June 1992, and logging by a local landowner.

3.14 WILDLIFE

3.14.1 Study Area

The overall study area for wildlife is also shown in Figure 3.14-1. The study area comprises distinct habitats which occur in a mosaic dictated by topographic and drainage patterns. The vegetation of the region is described above in Section 3.13.1.

3.14.2 Baseline Conditions Prior to June 1992

Methods

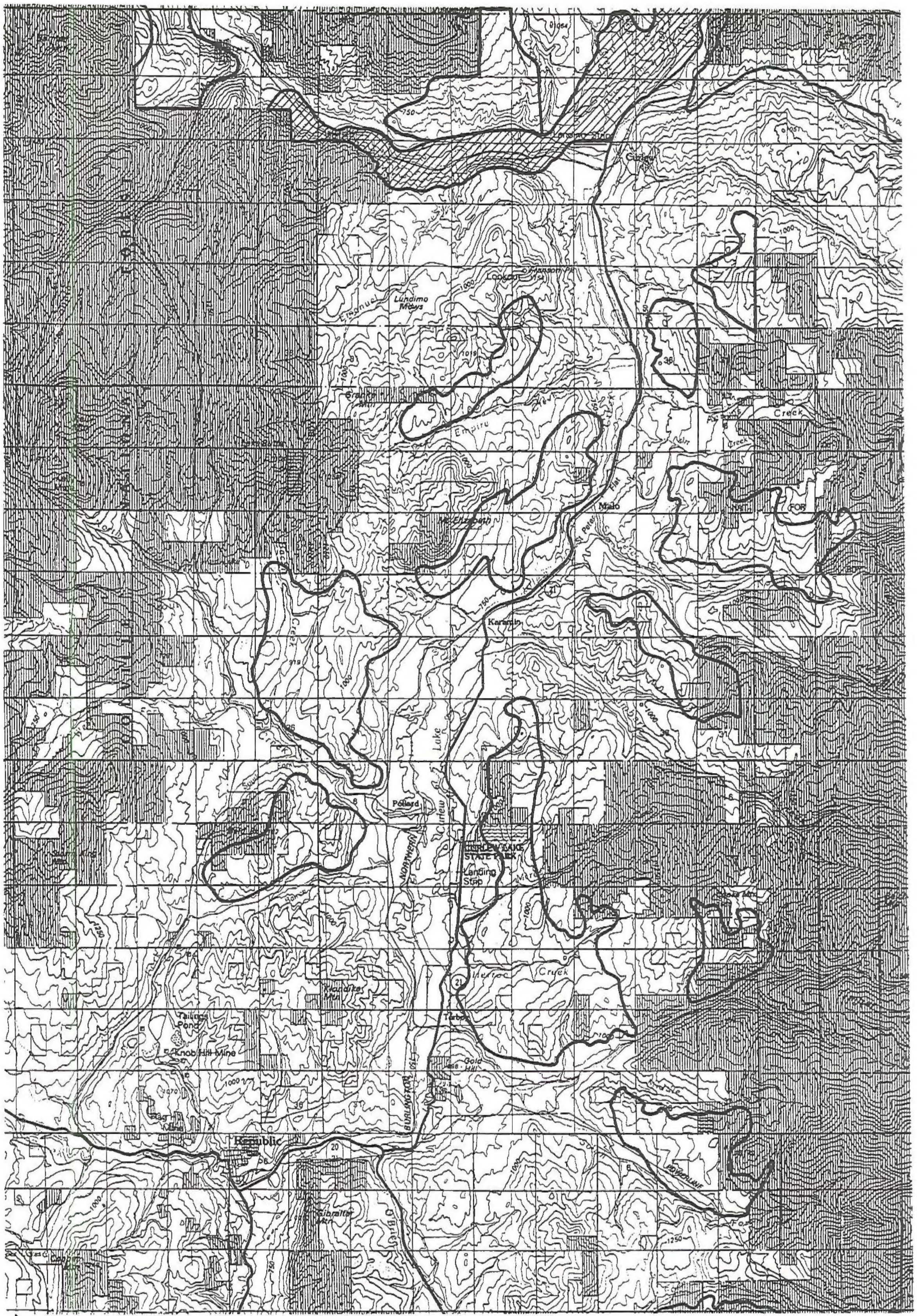
The existing wildlife resources of the Lamefoot site were evaluated on the basis of a review of existing information, including Washington Natural Heritage Database records of threatened, endangered, and special concern species in the state of Washington (Natural Heritage Data System, letter dated October 14, 1991); a botanical survey of the study area (Mastrogiuseppe Environmental Consultants 1991); and a site visit during October 1991 (Golder 1992c). In terms of detecting wildlife species in the field, the results are limited because summer resident birds had already migrated from the area, bats had either migrated or entered hibernation; and reptiles and amphibians were dormant. Many other species, such as small mammals, are inconspicuous and would require much greater time and effort to detect than a single site visit. The wildlife species observed during the field visit are typical of similar habitats in the region, and the habitat features present are widespread within the region. In addition to the species observed during the October 1991 field visit, at least 150 other wildlife species have been recorded from the region and the nearby Colville National Forest, and many of these species can be expected to occur at least occasionally in the study area. The limited data available are considered adequate to complete the evaluation of this EISS, given the limited surface disturbance expected, the existing and historic level of human related disturbance in the vicinity, and the fact that habitat identified as suitable for use by species of special concern will not be affected by the proposed project.

Habitats

The forest understory varies from dense shrubs to scattered shrubs and herbaceous vegetation. The density of the forest canopy ranges from closed to open. Large old trees, rock outcrops, snags, and plentiful down woody material are present and enhance wildlife habitat quality for diverse species such as nesting raptors, cavity-nesters, reptiles, bats, small mammals, and woodpeckers. This diversity of habitat types provides habitat in turn for a variety of wildlife species.

Openings of various sizes exist throughout the forested areas. Some openings support grassland habitats with only scattered shrubs. One large west-facing hillside east of Wolfe Camp Road is shrubland, with only a few scattered trees.

Patches of aspen and cottonwood, with shrubs such as redosier dogwood, ninebark, and willow occur in moist sites. Dense grasses form the ground cover in the more open canopy sites. Wetland areas are included in some of these sites, which exist along drainages, on slopes, and in depressional areas. Wetland areas are shown in Figure 3.13-1. These areas also include snags and abundant down woody material, thus providing habitat for cavity-users, woodpeckers, reptiles and amphibians, as well as many other species. Several small seasonal and permanent ponds, with margins of short emergent vegetation, exist along stream courses and



☐ MULE DEER WINTER RANGE

▨ WHITE-TAILED DEER WINTER RANGE

SOURCE: REPUBLIC USGS (1:100,000 MAP) AND WASHINGTON DEPARTMENT OF WILDLIFE, 1993

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

WILDLIFE STUDY AREA

DATE 11/12/93 SCALE FIG. NO. 3.14-1

in depressions. The ponds are often surrounded by aspens and/or cottonwoods. The mixture of conifers and hardwoods present provides habitat for a diversity of summer resident, migrant, and year-round resident birds.

Cliffs, rock outcrops, and talus slopes exist in the study area on steep terrain. These provide potential habitat for roosting bats, cliff and outcrop users such as Townsend's solitaires, yellow-bellied marmots, wood rats, shrews, mice, voles, reptiles, and amphibians (Golder 1992c).

Mammals

Mammals or recognizable signs observed during the October 1991 field visit included: coyote, deer (probably both mule deer and white-tailed deer, but none were observed — tracks, well-used trails, and scat were commonly observed), pocket gopher, red squirrel, snowshoe hare, vole, and yellow-pine chipmunk. Droppings from a medium-sized carnivore, within the size range of a small raccoon, fox, mink, marten, long-tailed weasel, or skunk were also observed at several sites in the study area. All of these species are known to occupy in this part of Washington and are likely to occur on the Lamefoot site, with the possible exception of the marten. Martens tend to occupy older, more contiguous forests but may occur.

The Lamefoot site is adjacent to, and includes an area of regular moderate concentrations of mule deer during the winter (Figure 3.14-1). It appears to be heavily used by deer. Numerous heavily used trails and droppings ranging in age from very old to very recent were observed throughout the study area. The visible trails traversed slopes above and below Wolfe Camp road. The Lamefoot area may be important year-round range for deer, given its relative abundance of forage in open areas and shrub understory areas, and adjacent closed forest providing thermal cover. It is probably important as winter range given its relatively low elevation and aspect, which may create extensive snow-free areas where deer movements are not inhibited by deep snow, and thermal cover is nearby. This area is probably used by both white-tailed and mule deer. A fair proportion of the regional study area shown on Figure 3.14-1 is classified as mule deer winter range. Owing to a lack of low-elevation quality winter range, mule deer tend to winter at 5000 feet or above on the tops of south-facing slopes which become snow free first, and use thermal cover provided by adjacent old growth forests (Palmenteer 1993).

Birds

Bird species or recognizable signs observed during the 1991 field visit included the following birds: an accipiter hawk (either a female Cooper's hawk or a male goshawk), American robin, black-billed magpie, Clark's nutcracker, common raven, evening grosbeak, golden-crowned kinglet, gray jay, hairy woodpecker, mountain chickadee, northern flicker, pileated woodpecker, pine siskin, red-breasted nuthatch, red-tailed hawk, and red crossbill. Over 100 species of birds can be expected to occur in the Lamefoot vicinity.

Reptiles and Amphibians

Owing to the timing of the October 1991 field visit, no species of reptiles or amphibians were observed at the Lamefoot site. Several species of reptiles and amphibians were considered likely to occur, including Pacific chorus frogs and garter snakes. No sensitive or special-status species were known to occur in the vicinity, or were considered likely to occur at that time, based on habitat conditions. (A discussion of the spotted frog is presented in the following subsection.)

Special Status Species

The Washington Natural Heritage Data System (information dated March 4, 1992) had no records of any rare, threatened, endangered, or otherwise special-status wildlife species within the area to be directly affected by the Lamefoot project. There were, however, records of several species of concern to the State of Washington from the vicinity. There was a nest record for the red-necked grebe on Curlew Lake (Section 5), and a nest record for the great blue heron (Section 8) near Curlew Lake. The grebe and heron are classified as State Monitor species, meaning that they are native to the State, and meet at least one of the following criteria, they: "1) were at one time classified as endangered, threatened, or sensitive; 2) require habitat that has limited availability during some portion of its life cycle; 3) are indicators of environmental quality; 4) require further field investigations to determine population status; 5) have unresolved taxonomy which may bear upon their status classification; 6) may be competing with and impacting other species of concern; or 7) have significant popular appeal. In the case of the grebe, criteria 2, 3, and 4 probably apply; while criteria 2, 3, and 7 likely apply for the heron. State monitor species will be managed by the department, as needed, to prevent them from becoming endangered, threatened, or sensitive" (Washington Department of Wildlife 1991).

Red-necked grebes nest over water, constructing mounds of vegetation in shallow water as nest sites. There is no such aquatic habitat in the Lamefoot project area. Great blue herons nest in colonies in large trees, building stick nests 1 foot or more in diameter. Forested slopes containing potentially suitable large conifers within the study area were examined through 10x binoculars from a variety of vantage points; no nests were observed.

A summary of the sensitive wildlife species occurring or possibly occurring in the project vicinity, and comments on their status, is given in Table 3.14-1. A large accipiter which may have been a northern goshawk (USFWS Category 2, Washington State Monitor) was observed, and a pileated woodpecker (Washington State Monitor) were observed on several occasions in the study area during the October 1991 field visit. The spotted frog (USFWS Category 2, Washington Candidate) may also occur in the lower wetlands near the core shed (Thompson 1993a).

Of the special status wildlife species listed by the USFWS (Revised 1993) none have been observed in the vicinity of the Lamefoot project. The gray wolf (Endangered), grizzly bear (Threatened), bald eagle (Threatened), California wolverine (Category 2), and North American lynx (Category 2) have been recorded in northeastern Washington and the Colville National Forest, but are unlikely to occur in the Lamefoot project area, given the presence of roads, residences, and mining activity.

3.14.3 Baseline Conditions After Lamefoot Exploration (after June 1992)

Methods

Changes occurring after June 1992 were investigated through a one-day reconnaissance in October 1993, contacts with U.S. Forest Service and Washington Department of Wildlife and BLM personnel (Wainwright 1993; Thompson 1993a; and Palmenteer 1993), and information requested from the Washington Department of Wildlife's Priority Habitat and Species program (correspondence dated October 11, 1993).

Habitats

Habitat quality in the Lamefoot site was vastly improved in the lower wetland area near the core shed after livestock were removed. These changes were described under vegetation (Section 3.13.3). Taller grasses in the wetland and upland areas (that were formerly grazed) provide enhanced forage and cover for a diversity of wildlife species ranging from mule deer to garter snakes and frogs. Other habitat characteristics remained basically the same as they were prior to June 1992, with a few exceptions. Habitat had been

TABLE 3.14-1

SUMMARY OF THE OCCURRENCE AND STATUS OF SENSITIVE, RARE, THREATENED, AND ENDANGERED WILDLIFE SPECIES IN THE PROPOSED LAMEFOOT PROJECT AREA

Species	Status	Comments
Northern bald eagle	US and Washington Threatened, BLM Sensitive	Unlikely to occur except as a transient or migrant, no suitable nesting or foraging habitat exists, may occasionally occur at Curlew Lake.
Peregrine falcon	US and Washington Endangered, BLM Sensitive	Unlikely to occur except as a transient or migrant, not documented in Colville NF, not observed during field surveys.
Pacific western big-eared bat	USFWS Category 2, BLM Sensitive	Unlikely to occur, not documented in Colville NF, suitable cave roosting habitat absent.
Gray wolf, Grizzly bear	US and Washington Endangered, BLM Sensitive	Unlikely to occur at the Lamefoot site based on level of disturbance and road density; recent sightings in northeastern Washington are increasing.
Pileated woodpecker	Washington Candidate species	Observed on site, may nest in vicinity.
Three-toed woodpecker	Washington Monitor species	Not observed; may occur as suitable habitat is present.
Northern goshawk	Washington Candidate species	Either a female Cooper's hawk or male goshawk was observed at the Lamefoot site in October 1991; could have been a resident or transient; likely to occur at least occasionally.
North American lynx	USFWS Category 2, BLM Sensitive	Not observed; unlikely to occur based on habitat conditions and disturbance level.

Source: Washington Department of Wildlife 1991.
Washington Natural Heritage Program 1990b.

reduced by mining exploration, roads, offices, and associated facilities over that available prior to June 1992. Approximately 18 acres were eliminated. The recovery of the formerly grazed area probably more than offsets the habitat losses that occurred after June 1992, because the recovered habitat is more valuable and unique in the area than the upland habitats now affected by the mining exploration operations.

Mammals

Small mammal populations are undoubtedly more abundant and diverse in terms of species composition in the area as a result of increased vegetative density, height, and structural complexity resulting from livestock removal. This in turn provides a larger prey base for predatory mammals, such as weasels and coyotes. Wintering mule deer can be expected to benefit considerably from the increased forage available as a result of livestock removal.

Birds

Increased small mammal populations mentioned above also provide an increased food supply for predatory birds, such as hawks and owls. The increased vegetation also provides a larger supply of seed, fruit, and insect foods; and more nesting and hiding cover for birds.

Amphibians and Reptiles

During the October 1993 site visit, a dead Pacific chorus frog was found on Wolfe Camp Road near the spring. Livestock removal has created improved habitat for reptiles and amphibians, especially in the lower area near the core shed.

Special Status Species

Thompson (1993b) indicated that he considered it likely that the spotted frog, now classified as Category 2 by the USFWS, occurs in the wetlands in and near the project site. This was not verifiable in the October 1993 field visit, because spotted frogs are not active during October in eastern Washington. The owner of the lower wetland area near the core shed office, Ronnie Hilderbrant (1993), was interviewed and stated that he had never observed frogs in this wetland. Removal of livestock from the lower wetland area has undoubtedly enhanced habitat quality and quantity for spotted frogs, if they do occur.

4.0
ENVIRONMENTAL CONSEQUENCES

4.0
ENVIRONMENTAL CONSEQUENCES

This section discusses the predicted environmental consequences (or impacts) of (a) the proposed action, (b) alternatives to the proposed action, and (c) a connected action (mill and tailings facility), as directed by NEPA and the CEQ and BLM regulations. Later subsections address (d) cumulative impacts, and (e) recommended mitigation, by discipline.

IMPACT METHODOLOGY

The methodology used for impact assessment is a simple one. Impacts are rated based primarily on professional and technical judgement in view of this particular project, its setting and context, other projects the EISS Team has reviewed, and the effects of this project in both a site-specific and regional sense. References to standards or criteria are often used to provide a context.

Discipline specialists rated the impacts generally using the following scheme:

IMPACT LEVELS

No Impact - No or negligible impact; no measurable or perceived effect.

Low - Little, minor or insignificant impact; magnitude and duration are slight; few indirect effects; mitigation is effective.

Medium - Moderate yet notable impact; both direct and indirect effects; some exceedance of standards or criteria; mitigation can address most effects.

High - Impact of a major, significant, and potential long-term nature; indirect effects are likely; magnitude and duration of impact are distinct and probable; likely to produce repeated and notable exceedances of standards and criteria; mitigation may not be able to address most effects.

IMPACT TYPES

Adverse - Effects of generally a negative or detrimental type; resource is depleted in quantity and quality.

Beneficial - These impacts are positive and improve the situation for this particular resource or topic; a positive change in the condition is likely to occur.

Many examples could be given to illustrate the above. However, individual judgements differ. The reader is urged to consult the individual sections which follow for the discipline of greatest interest.

4.1 GROUNDWATER

4.1.1 No Action

The groundwater impacts of the No Action Alternative would involve closure of the mine at its current phase of development. It is assumed, based upon the Lamefoot Exploration EA (Golder 1992*c*), that closure would include sealing of exploration boreholes at the surface, recontouring and revegetation of existing waste rock piles and sealing the main portal with a concrete bulkhead.

Drainage from mine workings would be decreased from the amounts measured during active exploration due to sealing of boreholes to reduce surface infiltration, and sealing the portal (which will cause the workings to resaturate to the approximate pre-mining piezometric level). If it is assumed that (a) surface infiltration can be reduced by 25 percent, and (b) that upon resaturation, groundwater in the mine would reach equilibrium, and inflow will no longer be induced by mine dewatering, then the total mine inflow is estimated to be about 6.25 AFY, as shown on Table 4.1-1.

This inflow would be expected to discharge from the resaturated mine as dispersed flow through fractures into the local bedrock, although it is possible that one or more fault or fracture zones of higher permeability may direct the outflow to springs or seeps. The potential for this discharge to become acidic is considerably lower than that for the full-scale mine because the existing workings are primarily within neutralizing limestone bedrock (see Section 4.3 for a full discussion of geochemistry impacts).

Discharges to the infiltration pond would cease with closure under the No Action Alternative. Any nitrates or other chemical constituents introduced to the groundwater from this source would slowly disperse with little or no additional impact. Some residual nitrates and dissolved minerals contained in the mine and the waste rock may also continue to leach into the local groundwater.

Post closure groundwater monitoring of the sealed workings and downgradient from the reclaimed wastepiles is committed (see Section 2.3.5) to determine if further mitigation is necessary to prevent or control acid rock drainage (see Section 4.16.1). With these factors in mind, groundwater quality impacts in the area of the Lamefoot mine of the No Action Alternative are rated low adverse.

For the mill and tailings facility under the No Action Alternative, continued operations may potentially affect the quantity and quality of groundwater in the vicinity of the mill. However, based on historical monitoring data, the existing tailings pond liner and underdrain system appear to be functioning satisfactorily and in conformance with Washington DOE permit conditions.

4.1.2 Proposed Action

4.1.2.1 Lamefoot Mine Area

The groundwater impacts of the proposed action would potentially affect the quantity and quality of groundwater in the study area and may impact private supply wells and ultimately the groundwater discharge to Curlew Lake. The estimated impacts during active exploration (existing condition), active mining and after mine closure are described below for specific components of the proposed action:

Underground Mine Workings

Flow of groundwater from the existing underground exploration/development mine workings is relatively low (estimated range 7 to 17.5 gpm with an annual average of about 10 gpm). The neutral pH of the mine discharge does not indicate a current concern with acid drainage (see Section 4.3). The current rate of flow from mine workings does not appear to have depleted flow from the spring located at the 2605 foot elevation in the Wolfe Camp drainage or the wetlands, although preexploration monitoring data are not available. These current conditions are a result of the exploration/development workings which extend to a maximum depth at the 2615 elevation and penetrate primarily limestone bedrock, which possesses substantial acid neutralization capacity.

During active mining and after closure, groundwater flow within the mine workings would occur in somewhat different hydrologic conditions than the exploration workings. The depth of the mined stopes is expected to extend down to the 2400 foot elevation at the northernmost 400 feet of the mine, and may reach the 2200 foot elevation, depending upon groundwater conditions encountered and the ore economics at the time the

TABLE 4.1-1

MINE INFLOW ESTIMATES[1]

Mine Phase	Inflow from Surface Infiltration	Inflow from Groundwater	Total Inflow
Exploration (current phase of development)	**8.35 AFY** (18.6 acre catchment area x 1.5 ft precipitation x 30% infiltration rate ≈ 8.35 AFY)	**8.35 AFY**	**16.7 AFY** (Based upon observed average inflow of ~10.4 gpm)
Active Mining (to 2400' level)	**18 AFY[4]**	**55 AFY[2]**	**73 AFY**
Active Mining (to 2200' level)	**18 AFY[4]**	**86 AFY[2]**	**104 AFY**
After Closure	**18 AFY[4]**	**0 AFY** (No inflow after mine resaturates to equilibrium)[3]	**18 AFY**
No Action	**6.25 AFY** (assume 75% of exploration infiltration)	**0 AFY**	**6.25 AFY**

Notes:

[1] Average annual flows in AFY = Acre Feet per Year; (1 AFY = 0.62 gallons per minute - gpm). Actual flows will vary with seasonal precipitation.

[2] Estimated based upon increased hydraulic head in deeper mine workings and assumed bedrock hydraulic conductivity of 0.7 gallons per day/ft^2 (0.09 ft/day) using line sink calculation. Assume inflow is reduced by 50% due to committed mitigation which effectively grouts all points of inflow > 1 gpm.

[3] Equilibrium is estimated to be reached when the mine resaturates to the 2750 feet elevation, which would require about 84 acre feet of inflow. This would occur approximately 4.7 years (assuming 18 AFY inflow) after mine closure.

[4] Assume surface diversion of run on above mine; 30% infiltration rate on 9.3 acres below (downslope of) diversion, and 100% infiltration rate on 9.3 acres above (upslope of) diversion.

mine reaches this stage of development. The rock type exposed on the stope walls and eventually used as backfill would be primarily clastic rock, which has greater acid generating potential and much less neutralizing capacity than the limestone bedrock.

During the current exploration/development phase of mining, the amount of inflow from surface infiltration is estimated to be about 50 percent of total inflow, or about 8.35 AFY (5.2 gpm). Slight amounts of subsidence predicted of the mine roof (see Section 4.4) would increase the fracture permeability and the amount of infiltration from precipitation over the mine. With full development of mine stopes, surface infiltration is predicted to increase up to about 28 AFY (17.4 gpm) due to increased infiltration induced by subsidence. As a committed mitigation measure, infiltration could be reduced to about 18 AFY (11.2 gpm) by diverting surface run-on away from the area of increased infiltration by construction of a diversion channel along the existing exploration road above the mine workings.

Table 4.1-1 shows estimates of mine inflow from surface infiltration and groundwater inflow for the various mining phases. These estimates depend upon certain simplifying assumptions and conservative estimates of effects of fracture permeability in deep mine workings and of the mine roof. Actual inflow rates will depend largely upon the locations, permeability, and hydraulic connection of fractures and faults in bedrock. Flows may be less than estimated if faults and fractures are not highly permeable and do not connect the mine workings with areas of stored surface water or groundwater. Flows may be higher than estimated if the mine intersects permeable faults or fracture zones that are connected to the saturated unconsolidated deposits in the Wolfe Camp drainage. Although the quantities of inflow are only estimates, the significant conclusion that can be drawn from this analysis is that total outflow at the maximum extent of active mining could be expected to increase several times over the flow from current exploration workings due to: 1) the increased fracture permeability affecting surface infiltration; and 2) the increased hydraulic head at depths and 3) the presence of a saturated alluvial aquifer overlying the deep workings (i.e., below 2600 feet). Details regarding the methodologies and assumptions used to estimate mine inflows are presented in the Groundwater Technical Memorandum (W-C 1994).

The flow from mine workings during active mining to the 2200-foot level is estimated to be 200 AFY, or 124 gpm. This flow rate is within the capacity of the infiltration pond, which is over 295 gpm, based upon percolation tests (Hydrometrics 1993). To reduce the magnitude of hydrologic impacts and to control the volume of mine water to be treated, Echo Bay has committed to two mitigation measures to reduce mine inflow (Sections 2.3.5.2 and 2.3.5.3. These include (1) a surface diversion to reduce surface water infiltration above the mine, and (2) a program of underground grouting to seal all locations of groundwater inflow greater than 1 gpm in the mine, as described in Section 2.3.5. With these measures, the estimated inflow to the mine at the 2200-foot level is reduced by 50 percent to about 104 AFY (64 gpm), and 73 AFY (45 gpm) at the 2400-foot level, as shown on Table 4.1-1.

At these estimated rates of inflow, the amount of groundwater in storage within saturated alluvium and fractured bedrock may be depleted, thus reducing the amount of inflow with time. If this occurs, depletion of the spring flow that contributes to replenishment of the wetlands may occur. This impact is therefore rated low adverse, because the wetlands can probably be maintained by surface and shallow groundwater flow from the adjacent drainage to the west, and also by seepage from the infiltration pond, which would receive the increased flow from the mine. If necessary, depletion of the wetlands could be mitigated by grouting to reduce mine inflows and possibly diversion of a portion of flow from the infiltration pond to the wetlands, although this would require DOE approval in accordance with State Waste Discharge Permit 8033 and monitoring of effects.

Upon mine closure with backfilling and construction of a concrete bulkhead to plug the main adit, the workings would fill with water to the approximate premining level (estimated to be 2700 to 2750 feet elevation), and inflow would be approximately equal to the amount of surface infiltration (i.e., 18 AFY or 11 gpm). Because of the permanent increase in fracture permeability of the mine roof (even with backfilling, surface diversion, and sealing of drill holes), the total outflow is expected to be somewhat greater than the flow from the current exploration workings. The post-closure discharge from the backfilled workings would probably be dispersed through small fractures in the bedrock, although it is possible that one or more fault or fracture zones of greater permeability may direct the outflow to springs or seeps. The discharge of mine water through permeable fracture zones will be minimized by the committed mitigation measure of grouting any sources of inflow greater than 1 gpm. The grout is expected to provide a long-term effective reduction of permeability to the rock zones that are grouted.

Water quality constituent concentrations within the backfilled workings and the immediately surrounding bedrock (upon and following closure) are expected to be higher than present conditions. The constituents which are expected to exceed State groundwater quality criteria (State of Washington Department of Ecology 1990) in the backfilled mine are pH, nitrate plus nitrite, sulfate, arsenic, iron, manganese, and total dissolved solids. With the exception of pH and nitrate each of these constituents currently exceed the State criteria in the majority of the background monitoring wells (see Appendix C-3). The localized changes in water quality are probably unavoidable and are rated low adverse.

With adequate sealing of the mine and diversion of surface inflows, as proposed, the volume of mine water outflow would be minimized. Because of dilution the alkalinity of background water chemistry, and the neutralizing capacity of limestone bedrock, the effects of lowered pH would be expected to be substantially attenuated in groundwater beyond the permit area. Since nitrate is produced from blasting during active mining, the concentrations of nitrate are expected to begin to decrease immediately following mine closure.

There is potential for discharge from the mine to become more acid with time and with the different rock types exposed during active mining and post-closure. (See Section 4.3 for a more complete discussion of potential impacts related to mine geochemistry.) If treatment of acid mine drainage becomes necessary during active mining, the existing Washington DOE Permit 8033 requires a discharge pH limit of between 6.0 and 9.0 and monitoring of nitrate and other water quality parameters for the infiltration pond. Assuming compliance with this committed permit condition and Echo Bay's commitment to treat mine discharge water for pH, nitrate, and other constituents, no substantive impact is foreseen due to acid drainage during active mining.

If acid discharge occurs post-closure, the effects would be more difficult to detect and treat because of the dispersed nature of discharge, although the estimated outflow rate (which is equal to inflow after the resaturated mine reaches equilibrium) is lower for post-closure than for the active mining phase (Table 4.1-1). A potential groundwater pathway from the mine to the project boundary would be due west through approximately 500 feet of bedrock, and then southwest through approximately 3000 feet of alluvium. As discussed above, because of attenuation, dilution, and Echo Bay's committed mitigation to limit the volume of water circulating through the backfilled mine workings, the impacts are not likely to extend beyond the permit area. Based upon these predictions, no post-closure groundwater quality impacts to domestic wells or to Curlew Lake are expected. The post-closure impacts of acid discharge are therefore rated low adverse. Because of the inherent uncertainty in these predictions, post-closure monitoring, hydraulic controls, and water treatment (if necessary) are recommended mitigation measures as described in Section 4.16.

Infiltration Pond and Sumps

Currently, water quality appears to be degraded locally by nitrate or other dissolved compounds in the mine discharge water. Such waters may migrate from the infiltration pond, or be present in seepage from the mine sumps, and in infiltration from waste rock stockpiles. The nitrates originate from the use of about 750 lbs/day of ANFO explosives during mine exploration and development.

The nitrate concentration from the samples of the infiltration pond ranges from 1.63 to 70.5 mg/l, with an average of 49.3 mg/l (which average exceeds the Washington State Department of Health drinking water maximum contaminant level and the Washington Department of Ecology groundwater standard of 10 mg/l. At an average flow of 16.7 AFY from the mine, the nitrate loading to the infiltration pond is about 2,238 lbs/year. Because of the high permeability of the alluvium and glacial deposits and the steep hydraulic gradient toward the west, it is possible that water quality may be impacted at private wells or at Curlew Lake during the life of the project (or after closure) since nitrate is not readily attenuated during subsurface migration. For comparison, other sources of nitrate loading estimated to affect Curlew Lake include surface water inflow; 3991 lbs/year, precipitation; 1389 lbs/year, residual groundwater; 4198 lbs/year, septic systems; 880 lbs/year, and internal loading; 11,025 lbs/year (Juul and Funk 1988).

Based upon the amount of explosives used, the mass of nitrate loading is expected to remain constant or decrease (due to source control measures discussed in Section 2.3.5.2) during exploration through active mining, although the flow to the infiltration pond is expected to increase during the active mining phase. After mine closure, nitrate loading is expected to decrease (since blasting will cease), although some residual nitrate in the mine and in the backfilled waste rock may continue to leach from the mine. During active mining, the nitrate, pH and dissolved metals will be monitored and treated as required prior to discharge to the infiltration pond. The treatment method and discharge limits are to be determined by Echo Bay and DOE respectively, as discussed in the Project Description, Section 2.0. Based upon this commitment this impact is rated low adverse. Monitoring of groundwater immediately west and north of the infiltration pond, and further treatment (if necessary) are recommended mitigation measures. The Hydrologic Monitoring Plan is described in Section 2.3.5.3

Water Supply Well

The mine water supply well is located approximately 40 feet east of the infiltration pond, and supplies the mine with an average 2,000 gallons per day for domestic use and drilling makeup water if necessary. The well produces from fractured bedrock at a depth of 265 feet. Because of the small amount of water produced from the well and the immediate sources of recharge from the nearby wetlands, the infiltration pond, and the nearby sewage leach field, no adverse impact is expected regarding depletion of water available to the spring, wetlands, or other private wells due to the mine supply well. However, of concern is the potential degradation of water quality of the supply well itself from the infiltration of mine water and sewage effluent. This concern can be adequately addressed by applicable Washington DOE and Department of Health permits, which contain monitoring requirements that apply to the infiltration pond and the well (which is, or will be regulated as a public water supply).

Private Supply Wells

Private supply wells in the study area include the Heckley, Corl, and Perkl wells as described in Section 3.1. No direct impacts to water availability or water quality for these wells are anticipated. As a condition of approval for the exploration permit, Echo Bay has agreed to monitor groundwater in order to identify potential impacts to any private water supplies and to restore or replace any supplies, that are adversely affected by project operations. It is recommended that this condition be continued during operation and post closure; see Section 4.16.

Waste Rock Storage

Temporary stockpiles of ore and waste rock are located east of State Highway 21 near old Wolfe Camp Road. These stockpiles are constructed on pads of acid-neutralizing limestone, and bermed to prevent contact with surface water. Because of the construction methods, the temporary nature of the stockpiles, and the relatively low amount of precipitation available to leach through the stockpiles, the potential for impacts on groundwater quality here are low adverse. Groundwater monitoring immediately west and south of the stockpiles for nitrates, metals, and pH are included as recommended mitigation measures in Section 4.16.

4.1.3 Alternate Backfill Access

The alternate backfill access tunnel would pass under the Wolfe Camp Road and drainage at a location approximately 2000 feet upstream from the spring in the Wolfe Camp drainage. Since the apparent source of the spring flow is saturated alluvium (which overlies a fault zone in the Wolfe Camp drainage as previously described), the tunnel may intercept groundwater and thereby decrease the spring's flow. The quantity of flow into the tunnel from the overlying alluvium would depend upon the depth of the tunnel, upon the fracture permeability of the bedrock, and the level of saturation of the alluvium, which will vary seasonally.

A substantial rate of inflow is possible in this tunnel because of three factors: (1) the presence of saturated alluvium above the tunnel; (2) the probable location of a fault zone along the drainage which would increase the potential occurrence of fractures; and (3) the absence of a great thickness of overburden in the drainage to compress the fractures and reduce their permeability. Exploration boring logs in the vicinity of the proposed tunnel show the occurrence of faults and fractures that are not filled by mineral deposits, indicating a probable zone of high permeability. A quantitative estimate of the inflow to the backfill access tunnel from the alluvium is not possible based upon information currently available. The potential impact is rated medium adverse.

If significant inflow to the tunnel occurs, the impact on the spring may be mitigated by lining the tunnel, sealing discrete zones of inflow, or by pumping the inflow separately from the mine inflow and discharging the flow to recharge the alluvium downstream of the tunnel.

4.1.4 Alternate Haul Route

No groundwater effects of any magnitude are predicted from implementation of the alternate haul route.

4.1.5 Alternate Sub-County Road Backfill Access

Groundwater impacts of this alternative backfill method would be similar to those of the Proposed Action. In general, alluvial groundwater would not be intercepted, as is possible for Alternative 2, because the sub-county road access enters the hillside above the elevation of the Wolfe Camp drainage floor. Runoff from the hillside above the road will percolate into the road cut and might produce some slight seepage into the access tunnel. Impacts are, therefore, rated low adverse.

4.1.6 Limited Mine Development - 2750' Level

The Limited Mine Development alternative involves open-stope mining above the 2750 foot elevation. This elevation was chosen because it represents the estimated post-mining water table elevation after the mine is sealed and becomes resaturated to equilibrium conditions.

During active mining, the groundwater inflow for this alternative is estimated to be less than the inflow for the proposed action because groundwater drawdown would not be induced below the elevation of current exploration workings. Some increased inflow relative to the exploration phase inflows is expected due to increased surface infiltration as a result of subsidence above the workings. Considering the catchment area above the mine, increased infiltration due to subsidence effects, and incorporating the planned installation of two surface diversion ditches above the mine, the amount of inflow from surface infiltration is estimated to be 12.6 AFY. This volume is based upon 30% infiltration over 9.3 acres plus 60% infiltration over 9.3 acres times 1.5 feet/year precipitation. Inflow from saturated groundwater flow into the workings is estimated to be equal to the amount of inflow to the existing exploration workings, i.e., 8.35 AFY. Total mine inflow for this alternative during active mining is estimated to be 12.6 AFY + 8.35 AFY = 21 AFY.

maximum contaminant level and the Washington Department of Ecology groundwater standard of 10 mg/l. At an average flow of 16.7 AFY from the mine, the nitrate loading to the infiltration pond is about 2,238 lbs/year. Because of the high permeability of the alluvium and glacial deposits and the steep hydraulic gradient toward the west, it is possible that water quality may be impacted at private wells or at Curlew Lake during the life of the project (or after closure) since nitrate is not readily attenuated during subsurface migration. For comparison, other sources of nitrate loading estimated to affect Curlew Lake include surface water inflow; 3991 lbs/year, precipitation; 1389 lbs/year, residual groundwater; 4198 lbs/year, septic systems; 880 lbs/year, and internal loading; 11,025 lbs/year (Juul and Funk 1988).

Based upon the amount of explosives used, the mass of nitrate loading is expected to remain constant or decrease (due to source control measures discussed in Section 2.3.5.2) during exploration through active mining, although the flow to the infiltration pond is expected to increase during the active mining phase. After mine closure, nitrate loading is expected to decrease (since blasting will cease), although some residual nitrate in the mine and in the backfilled waste rock may continue to leach from the mine. During active mining, the nitrate, pH and dissolved metals will be monitored and treated as required prior to discharge to the infiltration pond. The treatment method and discharge limits are to be determined by Echo Bay and DOE respectively, as discussed in the Project Description, Section 2.0. Based upon this commitment this impact is rated low adverse. Monitoring of groundwater immediately west and north of the infiltration pond, and further treatment (if necessary) are recommended mitigation measures. The Hydrologic Monitoring Plan is described in Section 2.3.5.3

Water Supply Well

The mine water supply well is located approximately 40 feet east of the infiltration pond, and supplies the mine with an average 2,000 gallons per day for domestic use and drilling makeup water if necessary. The well produces from fractured bedrock at a depth of 265 feet. Because of the small amount of water produced from the well and the immediate sources of recharge from the nearby wetlands, the infiltration pond, and the nearby sewage leach field, no adverse impact is expected regarding depletion of water available to the spring, wetlands, or other private wells due to the mine supply well. However, of concern is the potential degradation of water quality of the supply well itself from the infiltration of mine water and sewage effluent. This concern can be adequately addressed by applicable Washington DOE and Department of Health permits, which contain monitoring requirements that apply to the infiltration pond and the well (which is, or will be regulated as a public water supply).

Private Supply Wells

Private supply wells in the study area include the Heckley, Corl, and Perkl wells as described in Section 3.1. No direct impacts to water availability or water quality for these wells are anticipated. As a condition of approval for the exploration permit, Echo Bay has agreed to monitor groundwater in order to identify potential impacts to any private water supplies and to restore or replace any supplies, that are adversely affected by project operations. It is recommended that this condition be continued during operation and post closure; see Section 4.16.

Waste Rock Storage

Temporary stockpiles of ore and waste rock are located east of State Highway 21 near old Wolfe Camp Road. These stockpiles are constructed on pads of acid-neutralizing limestone, and bermed to prevent contact with surface water. Because of the construction methods, the temporary nature of the stockpiles, and the relatively low amount of precipitation available to leach through the stockpiles, the potential for impacts on groundwater quality here are low adverse. Groundwater monitoring immediately west and south of the stockpiles for nitrates, metals, and pH are included as recommended mitigation measures in Section 4.16.

After mine closure and resaturation to hydraulic equilibrium, inflow from saturated groundwater flow is estimated to become negligible. Inflow from surface infiltration is estimated to continue at 12.6 AFY; therefore, total mine inflow after closure would be 12.6 AFY. This volume is slightly less than the 18 AFY estimated for the proposed action (see Table 4.1-1) due to the inclusion of an additional surface diversion ditch which is estimated to reduce the amount of surface infiltration above the mine. The long-term impact to groundwater quantity is rated low adverse, similar to the proposed action.

The Limited Mine Development alternative would limit the volume of mine water that would be treated and discharged to the infiltration pond during active mining. Long-term water quality impacts are based upon post-closure conditions. Post-closure impacts of this alternative would be similar to the Proposed Action because (a) the volume of inflow is similar and (b) the greatest potential for development of acid drainage is in the upper zone of the mine where fresh mineral surfaces are exposed to oxygen and percolating groundwaters derived from surface infiltration. Therefore, the long-term water quality impacts of this alternative are rated low adverse, similar to the Proposed Action. No adverse impact to private wells outside the permit area are predicted to occur.

4.1.7 Limited Mine Development - 2741' Level

Impacts to groundwater would be the same as Alternative 5.

4.1.8 Mill and Tailings Facility

Long range plans for the Kettle River Project call for the periodic expansion of the tailings pond facilities as existing capacity is utilized, and as additional mining projects go with production. As a connected action to the proposed Lamefoot Project, the completed Phase IIA expansion involved the construction of a second pond located adjacent to the western side of the existing pond (Echo Bay 1993a) and added 1.2 million tons of tailings storage to the facility (Golder 1992b). This expansion utilizes a composite liner consisting of a layer of bentonite with an overlying VLDPE liner and an underdrain system similar to the Phase I design. The addition of a bentonite sheet will provide an additional level of containment, as well as allow more flexible water balance management by allowing the storage of water in the ponds without a layer of tailings present. A Phase IIB expansion is also planned, likely in 1994 or 1995. This expansion will consist of raising the height of the Phase I and Phase IIA tailings pond embankments to an elevation of 3245 feet, an increase of 25 feet. The underdrain systems will be extended up the backslope of both ponds and the additional area will be lined with a liner similar in design to the composite liner used in the Phase IA expansion. The Phase IIA and IIB expansions will bring the total capacity of the Phase I and Phase 11 tailings ponds to at least 5.89 million tons (Golder 1992b).

Based on current data indicating no evidence of cyanide in monitoring wells TP-1 and TP-2, it appears that the current liner, underdrain and pumpback system are effective. The more conservative Phase 11 design should prove even more effective in reducing cyanide leakage through the tailings ponds. However, as noted in Section 3.1.2.2, cyanide was detected in the underdrain system during start-up of the facility. It is possible that minor leaks related to liner construction may also occur upon start-up of the Phase IIA tailings pond. However, due to the additional protection afforded by a composite liner, any leakage is expected to be minimal and should be contained and pumped back to the pond by the underdrain collection system. The monitoring and pump back systems are operated in accordance with existing DOE Permit 8033.

As an expansion of the downgradient groundwater monitoring system, Echo Bay has installed an additional monitoring well (TP-3). Based on available piezometric surface information, this location is thought to be downgradient of the tailings pond expansion. However, the wells are not located such that the piezometric gradient can be determined.

downgradient of the tailings pond expansion. However, the wells are not located such that the piezometric gradient can be determined.

Expansion of the tailings pond has reduced the area of infiltration and may affect recharge to the groundwater flow regime, similar to the effects of the Phase I construction. It is likely that the local potentiometric surface may be lowered, resulting in diminished flow from springs or seeps along the bank of the North Fork of the Sanpoil River.

Based on the results of the DOE study referenced in Section 3.1.2.2, it is unlikely that pumping at current rates from the existing groundwater wells supplying the Key Mill would adversely affect other groundwater users. However, if Echo Bay were to increase pumping from these wells, adverse impacts to other users might occur.

Echo Bay has developed a spill prevention, control, countermeasure and emergency response plan. The purpose of this plan is to identify potential sources of petroleum, petroleum products and mill reagents contamination, describe existing preventive measures, and establish procedures for responding to spills of these materials. This plan is updated yearly.

Stockpiling of ore at the mill would be temporary (up to 2 months) and would be conducted on pads of compacted native soils which prevent contact with surface water. No additional impact is expected due to the connected action.

The slight increases in potential groundwater impacts from the expanded mill and tailings facilities are rated low-adverse.

4.2 SURFACE WATER

4.2.1 No Action

Compared to pre-exploration baseline conditions, only minor surface water impacts are expected to result under the No Action Alternative. Sealing of the mine will eliminate the point source discharge to the infiltration pond, and only discharge from the workings would be as diffuse seepage that would be similar in quantity to baseline conditions. Water quality may be adversely affected, however, in the Wolfe Camp drainage, particularly if acid drainage conditions develop (Section 4.3). Since the possibility of acid drainage is very slight for this alternative, the surface water impact is rated low adverse.

Reclaimed surface waste piles, roads, and mine area features would be recontoured and revegetated to minimized erosion sediment transport. Short-term and localized sedimentation may occur during reclamation activities. After vegetation is established, no continued surface water quality or quantity impacts are expected to occur. This impact is rated low adverse.

4.2.2 Proposed Action

Surface water impacts resulting from the proposed action in the Lamefoot project area include:

- Localized sedimentation in the Wolfe Camp drainage
- Indirect water quality impacts during active mining due to discharge of mine water to the infiltration pond
- Post-closure water quality effects of seepage from backfilled mine workings, and due to runoff from the quarry and reclaimed disturbed surface areas

The potential surface water impacts are minimized because no direct discharges are expected to surface water bodies, and the Plan of Operations (Echo Bay 1993a) includes plans to control surface water contact with temporary stockpiles of ore and waste rock during active mining, and after reclamation.

Surface water quality may be indirectly affected by the discharge of mine water to the infiltration pond. This impact is discussed as a groundwater impact in Section 4.1. Over time, the affected groundwater may resurface at the wetland immediately north of the infiltration pond or at Curlew Lake. The most appropriate established mitigation of this potential impact is proper monitoring and enforcement of existing DOE Waste Discharge Permit 8033 during active exploration and mining.

Over the long-term, surface water may be degraded locally due to seepage of groundwater from the backfilled mine. Because of the low mine inflows and lack of a direct surface water flow pathway, Curlew Lake and regional rivers are not likely to be substantially affected. The most likely impact will be possible increased dissolved constituents in springs or seeps that contribute to surface water in the Wolfe Camp drainage. This impact is expected to be minimal unless the mine discharge becomes acidic, as discussed in Section 4.3. Recommended monitoring and mitigation measures for this potential impact are described in Section 4.16, under the Groundwater and Geochemistry disciplines.

Direct impacts to surface water quality may result from runoff and erosion of the backfill quarry, waste piles, mine portal area, mine portal roads, and other disturbed areas. The primary impacts expected are increased dissolved solids, suspended sediments, and minor leaks of petroleum from vehicles. These impacts are rated low. Committed mitigation includes construction of runoff detention berms and diversion ditches. Recommended mitigation measures are described in Section 4.16.

Groundwater monitoring at springs, wells, and backfilled mine workings as recommended in Sections 4.1 and 4.16 will also be effective to identify and mitigate potential surface water quality impacts.

4.2.3 Alternate Backfill

The alternate backfill method will have a marginally reduced impact on Wolfe Camp Road disturbance and, therefore, impacts to the water quality and sedimentation load in the watershed are rated low adverse; the same as for the Proposed Action backfill impacts.

4.2.4 Alternate Haul Route

Slightly increased impacts to surface water quality associated with an alternative haul road may be created by increased disturbance and sedimentation caused by traffic on gravel road surfaces. It is anticipated that any increase in sediment yield to the Sanpoil River caused by increased alternate haul road usage will be insignificant in comparison to the existing sediment loads caused by the existing roads and logging within the watershed.

4.2.5 Alternate Sub-County Road Backfill Access

Surface water impacts of this alternative backfill method would be similar to those of the Proposed Action and are rated low adverse.

4.2.6 Limited Mine Development - 2750' Level

Slightly decreased potential impacts to surface water quality from this alternative are likely as a result of the smaller area of the backfill quarry. However, since runoff from the quarry will be controlled with berms the surface water impacts of this alternative are estimated to be similar to the Proposed Action and are rated low adverse.

4.2.7 Limited Mine Development - 2741' Level

Surface water impacts of this alternative are expected to be similar to those of Limited Mine Development to the 2750 foot level and the Proposed Action and are rated low adverse.

4.2.8 Mill and Tailings Facility

The expanded Key Mill tailings facility have not and are not expected to have adverse impacts of note to surface water quality and quantity.

4.3 GEOCHEMISTRY

Potential impacts from geochemical processes would predominantly affect surface and groundwater resources. As such, much of the pertinent discussion of environmental consequences is included in Sections 4.1 and 4.2. This section will focus on geochemistry issues, specifically concerning potential acid drainage and associated water quality degradation.

4.3.1 No Action

Under this alternative, the exploration workings would not be backfilled with the existing waste stockpile materials, but the stockpiles would be recontoured and revegetated in place. Exploration boreholes would be sealed at the surface and the main portal would be sealed with a concrete bulkhead backfilled and recontoured. The exploration activities have created increased surface area for potential chemical reaction of seepage waters with exposed ore, waste rock and backfill, as compared to the premining conditions. However, because the existing exploration workings are (1) largely within limestone, (2) have been open for a relatively short time, and (3) have in general not been contacted by groundwater seepage, little or no degradation of groundwater quality has occurred. Such degradation is unlikely in the future, since the main portal will be sealed and a relatively small amount of water would be involved. Thus, the potential impacts of seepage from the mine workings on local water quality, both surface and groundwater, for the No Action Alternative are considered to be low adverse. Similarly, the potential impacts of seepage from revegetated ore and waste stockpiles on local water quality for this alternative are considered low adverse.

4.3.2 Proposed Action

Closure conditions for the proposed action are quite similar to those of the No Action scenario. That is, the mine workings would be backfilled with both (1) waste rock from stockpiles near the portal, and (2) backfill materials from the Wolfe Camp Road quarry. Approximately 84 percent of the backfill is estimated to be taken from the Wolfe Camp excavation, which is composed largely of clastic materials (Echo Bay 1993b). Roughly 345,000 tons of this backfill will be cemented backfill and 1,268,000 tons will be uncemented (Golder 1994). Cement will comprise about 17,000 tons or about 1.0 percent of the backfill materials (see Figure 3.3-3). Further, exploration boreholes would be sealed, and the main portal would be plugged with a concrete bulkhead, covered with backfill waste and recontoured. However, relative to the No Action Alternative, the workings would be substantially expanded and deepened, with additional areas of clastic rock being exposed. It is also likely or probable that mine inflow may increase (see Section 4.1), allowing for more chemical reaction of water and rock. In addition, and as noted above, backfill materials will be excavated from the Wolfe Camp quarry, thus exposing greater surface areas of clastic materials, which may generate net acid and increase concentrations of soluble constituents and suspended solids.

As such, the following impacts may result from the proposed action:

Operations

- Water quality within the mine workings during the operational phase will be somewhat degraded relative to background. However, the overall mining activities are not expected to degrade groundwater quality outside the permit area boundary during operations. That is, groundwater quality is not expected to be degraded relative to background at the permit area boundary.

The groundwater quality data included in Appendices B-2 and C-3 show that, prior to full-scale mining, the infiltration pond (LF-I) and the monitoring well waters (LF-1 and 2) already exceed the Washington groundwater criteria at selected times for nitrate, manganese, and iron. The specific conductance data suggest that TDS, while not determined at LF-I, also already exceeds the standard. Data from monitoring wells LF-1 and LF-2 (which are reported as dissolved concentrations versus the criteria, which are totals) show that some determinations of arsenic, lead, iron, manganese, selenium, TDS, and sulfate exceeded the State water quality criteria during the period April 1992 to October 1993. The presence of significant TSS concentrations in these LF-1 and LF-2 samples raises some concern about the reliability of these data, since it appears that these samples were acidified and filtered in the lab, which would probably yield higher metal concentrations than if samples had been field-filtered and then acidified prior to shipment to the lab.

Mine inflow samples collected from the workings during March 1993 (see Table 3.3-1) also show that some determinations of TDS, nitrate, sulfate, manganese and iron exceeded State groundwater criteria. Some of these underground samples also show elevated ammonia concentrations (40.4 and 90.3 mg/l).

Water quality samples collected in September 1994 showed that several wells to the west of the mine site have elevated nitrate concentrations (see discussion in Appendix C-3). It is possible that these elevated concentrations are due to mining activities, but it is also possible that they may result from several other processes such as: drainage from septic tanks and leach fields, contamination by breakdown products from organic-rich sediments, nitrogen-rich fertilizers and other agricultural products. The exact cause cannot be determined with the present data.

Hence, Echo Bay has agreed to implementation of an expanded monitoring program that would increase the frequency and geographic scope of the present groundwater monitoring. These expanded activities would better delineate the local nitrate patterns and nitrate background concentrations. In addition, these activities should identify the source of the elevated nitrate concentrations. Should Lamefoot Mine activities be identified as the major cause of the elevated nitrate concentrations near the western property boundary, Echo Bay has committed to the following source control activities:

1. Blasting Explosives. The blasting explosives mix would be altered to reduce, to the extent practical, the development of water soluble nitrates. This would be accomplished by substituting emulsion explosives for ANFO.

2. Increased Discharge Water Control. Echo Bay would reduce discharge from the sump system and would commit to manage any waters discharged to meet State discharge permit requirements.

It is assumed that water in the mine workings during the operational phase will have a pH above 6.5 (probably between 6.5 and 8.0). Given the site hydrogeochemical environment, it is likely that total concentrations of sulfate, total dissolved solids, arsenic, manganese and iron will exceed Washington State water quality criteria for groundwaters in water discharging from the mine portal (as presently determined at the infiltration pond, station LF-I). These predicted impacts are based on the fact that mining will increase the potential surface area available for rock-water interactions, thereby increasing the dissolved concentrations of many constituents. This increase in exposed rock would also heighten the possibility of oxidizing pyrite-rich materials, which might lower the pH. It is also possible that mine discharges of nitrates and nitrites may exceed Washington State groundwater quality criteria in the mine water. However, if initial control measures were unsuccessful, then mitigation would involve water management to bring any discharge levels into compliance with the State waste discharge permit.

The previously-described changes in mine discharge water quality are not expected to have significant impact on groundwater quality outside the permit area boundary because:

- Most of the mine inflow will not be discharged, but will be utilized in normal mine operations;
- Source control of nitrates by changing explosives;
- The volume of mine water actually released during operations (i.e., up to 64 gpm) will be discharged in accordance with the conditions required by DOE Permit 8033.

The low volume of present mine inflow, significant buffering capacity of local limestones, and relatively low permeability of the site rocks all act to minimize the potential for water quality degradation.

Lastly, water quality is not expected to be substantially degraded relative to background water quality at the permit area boundary because Echo Bay has committed to mitigate water quality problems as they may arise during operations and post-closure (see Section 2.3.5). It is assumed that these mitigation measures would lead to no substantive impacts to groundwater outside the permit area boundary and thus, no impacts to groundwaters are expected to occur between the Lamefoot mine and Curlew Lake during operations. In the event that it became necessary, Echo Bay would implement a water treatment program or other suitable mitigation.

Post-Closure

- Water quality within the backfilled mine workings, post-closure, will become degraded over time relative to baseline conditions. However, it is anticipated that there will be no significant adverse impacts to groundwater quality outside the permit area boundary post-closure. That is, groundwater quality is not expected to be degraded relative to background water quality outside the permit area boundary.

Plugging of the workings following cessation of mining has a high probability of preventing mine waters from seeping out into any local surface or groundwaters. Also, such plugging would eventually flood much of the workings, lowering the dissolved oxygen concentration, and would reduce rates of sulfide oxidation. However, plugging the workings does not completely remove the possibility of water quality degradation within the workings. The presence of only approximately 0.5 mg/l dissolved oxygen, or moderate concentrations of ferric iron, or both, in these waters along with Thiobacillus bacteria, might cause sulfide oxidation to continue (Hutchinson and Ellison 1992).

Given the results of the ABA testing for the waste and wall rock and the nature of the ore and overall site geochemistry, a reasonably foreseeable condition (as defined in NEPA CEQ regs., 40 CFR 1502.22) in post-closure conditions (after the portal is plugged) is one in which the waters contained within the workings will have a pH of between 4.0 and 6.0. Such waters will have reduced dissolved oxygen (D.O.) concentrations and Eh (redox potential) as compared to levels during mine operation. As such it is likely that, post-closure, total concentrations of sulfate, total dissolved solids, arsenic, iron, and manganese will exceed State groundwater quality criteria in the plugged workings. It is also possible that the total concentrations of nitrogen forms (nitrate, nitrite, ammonia) may exceed State criteria in the workings water immediately after closure, but should decline with time.

It is further reasonable to assume the previously-noted constituents will exceed State criteria in the plugged workings, since these constituents already exceed the criteria in many samples collected from wells LF-1 and LF-2 (see Appendix A-2). As described in the Operations portion of this section, samples collected from the settling pond (LF-I) already contain concentrations of manganese, iron and nitrate/nitrite that exceed the State criteria. The TDS at LF-I probably also exceeds the criterion of 500 mg/l, since the specific conductance ranged from about 1300 to 2200 micromhos/cm. Also, mine inflow samples and samples from the spring, the mine sump, and the bedrock supply well (see Table 3.3-1) tend to support these predictions of post-closure water quality in the workings.

Despite the degraded post-closure water quality within the plugged workings, no significant impact is expected to groundwater quality outside the permit area boundary because:

- post-closure mine outflows are estimated and calculated to be on the order of 10 gpm (see Table 4.1-1);
- the relatively small volumes of mine water (~ 10 gpm) discharging by all pathways will be greatly diluted by the much greater volumes (on the order of 10x to 100x) of alkaline waters present in the unimpacted bedrock and alluvium;
- alkaline waters in the natural limestone barrier will remove some dissolved constituents and provide buffering of pH. Metals such as iron, cadmium, manganese, zinc, lead, arsenic and copper would be greatly attenuated if released into the groundwaters west of the mine workings. Such attenuation would be partly caused by a reduction in solubility as a result of dilution and neutralization by the high alkalinity local groundwaters. In addition, attenuation would occur because of adsorption of metal cations on the surfaces of clays, iron oxyhydroxides and other charged surfaces, and by ion exchange. Manganese and zinc may be somewhat more mobile than most of the other metals in this environment. Anions such as sulfate and nitrate are much less attenuated by adsorption, iron exchange or oxidation-reduction reactions than metals. Their concentrations would decline more via simple dilution and to source extent chemical reaction.
- the previously-mentioned commitment by Echo Bay is to complete a study of appropriate treatment methods and to mitigate water quality problems as they may arise during operations and post-closure.

The previously-mentioned reasonably foreseeable condition (40 CFR 1502.22) of pH between 4.0 and 6.0, and elevated concentrations of selected constituents (relative to baseline), may not occur immediately upon closure. Data from the literature and field experience at many other mines indicate that these chemical changes may occur over many years after closure. Since about 21 percent of the backfill will be cemented, reaction of the cement with the inflow waters will further slow down the expected pH decline. Such positive effects of cemented backfill on post-closure water quality are expected, but have not been fully documented as yet in the technical literature. As such, decisions about the need for implementing any appropriate treatment/mitigation measures would be based upon operational and post-closure monitoring data from upgradient and downgradient wells and springs, as described in Section 2.3.5.4.

Attempts at using transport and chemical equilibrium modeling in this hydrogeologic setting would yield imprecise results largely because of the great uncertainty involved in the attenuation characteristics and the fractured nature of the aquifer.

- Overall post-closure groundwater quality impacts outside the workings (but within the permit area boundary) are predicted to be low adverse, since total dissolved solids, sulfate, iron and manganese concentrations will likely exceed State criteria in limited areas.

Criteria and Standards

Washington groundwater criteria have been mentioned throughout Section 4.3.2 for comparative purposes only; they will not necessarily be used as discharge standards at the Lamefoot site. Such standards would be determined by the Washington DOE, and set out in the appropriate State discharge permits which will consider the natural background levels.

Additional Ore, Waste Rock and Backfill Impacts and Sampling

- Surface stockpiles of ore have some limited potential for degradation of local surface and groundwater quality. Such potential impacts are likely to be minimal, since individual ore stockpiles would be exposed on the ground surface for only a period of weeks prior to shipment to the mill.

- Approximately 260,000 tons of waste rock are presently stockpiled on the ground surface near the mine portal. Early in the operational phase, about 60,000 tons of this material will be taken back underground as backfill. Near the time of mine closure an additional 100,000 tons of waste rock will be returned to the workings as backfill. This would leave about 100,000 tons of waste rock on the surface near the portal, which will be required for recontouring of the portal area. It will then be covered with topsoil and then revegetated. Thus, the volume of waste rock on the surface will decrease. Some waste rock has already been in surface stockpiles for approximately two years, and shows no evidence of generating water quality problems. Also, the majority of present waste rock piles is limestone, which tends to be neutralizing.

- As part of the monitoring program, Echo Bay has committed to perform one static test per 2000 tons of future underground waste rock for characterization purposes. However, this rock will never report to the surface.

- The existing limestone basal material is the only rock planned to be left on the surface post-closure, and will be used in reclamation of the portal area.

- The Wolfe Camp Road quarry will be mined for additional backfill materials, some of which have the potential to be acid-generating. The presently-exposed quarry materials show no evidence of causing water quality degradation. Surface water runoff from the quarry will be controlled by the construction of diversion structures. Enlargement of the existing quarry is not expected to result in any significant degradation of surface or groundwater quality. If such degradation were to occur, it would be detected in the downgradient monitoring wells.

Summary of Geochemical Impacts of the Proposed Action

In summary, the post-closure impacts of the proposed action from a geochemistry/water quality perspective are further refined in this FEISS, as follows:

1. **Inflows to the underground mine workings post-closure** are estimated at **11 gpm (18 AFY) at equilibrium conditions.** Inflow will approximate outflow during this period.

2. **Water seeping into the mine** will be controlled to some extent by the mine design changes committed by Echo Bay (See Section 2.3.5). **Buffering** of acid-producing areas by limestone wall rock and cemented backfill will occur. About 44% of the wall rock will generate net acid. However, there is no acid seepage into current exploration workings. The pH of the water impounded behind the workings post-closure is expected to be between 4.0 and 6.0.

3. **Outflows from the underground workings (via diffuse fractures, downgradient)**, after bulkhead sealing of portals post-closure, will approximate inflows, **at about 11 gpm**. This statement assumes water will flow into the workings and fill to about the 2750-ft elevation over an estimated 5-year period following closure. These inflows are estimated from Section 4.1, Table 4.1-1.

4. **Movement of water from the mine workings** to the property boundary is estimated at a **flow rate of about 18 acre feet per year (11 gpm)**. Water will leave the mine in a dispersed fashion through numerous small fractures. Dilution, attenuation, and mixing will occur. The mixing rate (with water already in the system) is estimated to range from 10:1 to 100:1.

5. **At the permit boundary**, the likelihood of various indicator parameters (see Section 2.3.5) **exceeding the range of background concentrations within 30 years post-closure is as follows:**

    - **field pH** - low (recall that impacts at this level are little, minor, or insignificant effects with slight magnitude and duration, few indirect effects; mitigation is effective)
    - **specific conductivity** - low
    - **total alkalinity** - low
    - **iron** - medium (recall that impacts at this level are moderate yet notable, produce direct and indirect effects, and some exceedance of standards or criteria; mitigation can address most effects)
    - **manganese** - medium
    - **zinc** - medium
    - **sulfate** - medium
    - **nitrate** - low
    - **TDS** - medium

6. As a result of the above, it is estimated that the **probability of the eventual need for a water treatment plant** in the post-operation phase **is low.**

7. Based on all of the above factors, the **geochemistry impacts of the proposed action** are rated **low adverse** (recall that adverse impacts are generally negative or detrimental; resource is depleted in quantity and quality).

4.3.3 Alternate Drop Pass Backfill Access

As discussed in Section 4.1.3, the alternative drop pass backfill access tunnel has the potential to intercept substantial additional groundwater inflow. If significant inflow is encountered, it could increase somewhat the oxidation of pyrite and dissolution of other minerals; some lowering of pH could result. Based upon data from a May 1994 horizontal borehole which found small inflows of 2-3 gpm, it appears likely that groundwater inflows resulting from Alternative 2 would be greater than from the Proposed Action. Thus, some additional, minor water quality degradation could result from the drop pass backfill access relative to the Proposed Action. As a result, the overall potential geochemical impacts to water quality from this alternative are rated medium adverse.

4.3.4 Alternate Haul Route

No geochemistry/water quality impacts of note are predicted from implementation of this alternative.

4.3.5 Alternate Sub-County Road Access for Backfill

It is assumed that groundwater inflow volume to the proposed adit for this alternative will be comparable to underground inflows for the Proposed Action. As such, overall potential geochemical impacts are anticipated to be comparable to those for the proposed action and are rated low adverse.

4.3.6 Limited Mine Development - 2750' Level

Geochemical impacts of the Limited Mine Development alternative are expected to be improved relative to the proposed action, but are also rated as low adverse. This conclusion is based on the following reasoning:

During Operations

- Geologic materials to be mined above the 2750 foot elevation are generally similar to those at lower levels as far as their tendency to generate acid (ABA characteristics).
- The limited mine development requires only about half the volume of backfill as the proposed action, i.e. approximately 697,000 tons versus 1.4 million tons, respectively.
- As stated in Section 4.1.6, the volume of total mine inflow during operation is expected to be somewhat less than for the proposed action.
- Geochemical conditions within the workings for both this option and the proposed action would be oxidizing. The expected life-of-mine for this option is between 2.0 and 2.5 years. As such, water quality within the workings is expected to be similar to that of the underground seep samples shown in Table 3.3-1.
- Because total mine inflow is less than that for the proposed action, groundwater quality is not expected to be degraded relative to background at the permit area boundary.

Post-Closure

- Geologic materials mined underground in both this option and the proposed action are generally similar regarding their tendency to generate acid.
- Preliminary visual observations of the materials to be quarried under the limited mining alternative suggests that these materials are of better quality than the materials quarried in the proposed action, in that they appear to have low acid-generating potential.
- The volume of total mine inflow, post-closure, would be slightly less than for the proposed action. As such, once an equilibrium water level is attained post-closure, the outflow volume from the mine would be somewhat less than for the proposed action.

- Oxidation of sulfide-bearing minerals would still occur above the water table, but there would be little or no water ponded within these workings. Instead, the water would be provided within the existing exploration workings below the 2750-foot elevation. Thus, there would be a smaller volume of degraded water within workings in the limited mine alternative as compared to the proposed action.
- Design features intended to improve the quality of the backfill materials (see Section 2.4.5) would improve the post-closure water quality in the workings as compared to that predicted for the proposed action.
- The total surface area of geologic materials exposed and available for chemical reaction would be reduced in the limited mine alternative relative to the proposed action.
- Based on all of the above factors, there is a high likelihood that water quality at the permit boundary 30 years post-closure would be similar to that expected for the proposed action.

Thus the geochemistry-related impacts of the limited mine development alternative are rated **low adverse.**

4.3.7 Limited Mine Development - 2741' Level

Geochemical impacts are expected to be the same as those for limited mine development to 2750', and are rated low adverse.

4.3.8 Mill and Tailings Facility

Details regarding project facilities and groundwater impacts of the mill and tailings facilities and the proposed expansion are discussed in Section 4.1.8. As described there, the mill and tailings facilities are considered connected actions, and are not part of any of the alternatives presently under consideration. These facilities are permitted by the Washington Department of Ecology-DOE.

The tailings are composed of ore which has been milled and then oxidized and leached in the presence of a cyanide solution. Normally, many types of reagents are added during ore processing (such as acids, bases, and other compounds). Under proper operating conditions none of these compounds are of concern except cyanide, as discussed below.

In the present system, leached ore in the cyanide-bearing solution is treated in a cyanide destruction plant (INCO SO_2 system). Many of the reagents, including cyanide, go to the tailings pond in the form of altered breakdown products. After the cyanide destruction circuit, tailings waters are deposited in the impoundment at a pH of about 8.0, and occasionally between 9.0 and 10.0. Such relatively high pH tailings waters may contain mobile oxyanions of constituents such as arsenic, selenium, and molybdenum, as well as high concentrations of nitrate, ammonia, sulfate, chloride, and possibly dissolved or total organic compounds. While the present tailings pond and the expansion pond are lined ponds (and intended to be zero discharge sites), there exists some potential for leaks to the local groundwater (Section 4.1.8). Such potential leaks would most likely have a high pH, if they occurred (1) during periods of active mill operation, or (2) for several years after shutdown. Many years after mill de-activation, it is possible that leaks could have reduced pH if significant amounts of unoxidized sulfur remained in the tailings. Potential impacts from the expanded mill and tailings facilities are rated low adverse, assuming the ability of the intact liner to handle low (1.0) to high (11.0) pH conditions as verified by the manufacturer (Cadwallader 1994).

At present there is no evidence of leakage from the tailings through the liner system into local groundwater. Responsibility for monitoring of water quality in the tailings area rests with the Washington DOE.

Nevertheless, some general monitoring suggestions have been included in Section 4.16 on recommended mitigation, and committed by Echo Bay in Section 2.0, as previously mentioned.

4.4 GEOLOGY AND SUBSIDENCE

This section will address potential geologic, topographic, and subsidence impacts from no action, the proposed action, and alternatives. Topics such as reclamation, visual impacts, and hydrologic effects are briefly mentioned as they may be affected by subsidence. However, the reader should consult the relevant section (e.g., Section 4.5 -Aesthetics) for more details.

4.4.1 No Action

The environmental consequences of the No Action alternative with respect to geology and subsidence are the result of the 210,000 tons of waste and 100,000 tons of ore extracted from approximately 16,500 feet of 16-foot wide by 14-foot high exploration openings. The exploration openings will provide a low resistance flow path to the portal to drain approximately 10 gpm of groundwater presently intercepted by exploration openings. Mitigation of this impact will involve installation of a watertight bulkhead to (a) impound this water within the mine; and (b) return the groundwater entering the exploration openings to the pre-exploration groundwater system. The bulkhead would likely be designed to withstand a maximum head of approximately 650 feet. The bulkhead would be placed at a sufficient distance inside the portal to eliminate the possibility of hydrofracturing the adjacent rock under the maximum 650 feet of hydraulic head, and releasing the maximum 3,710,000 cubic feet of water impounded in all the exploration openings to the ground surface. Overall, no impacts are expected.

4.4.2 Proposed Action

The proposed action is to develop and operate an underground mine, as previously detailed in Section 2.0. The potential environmental impacts of underground mines occur where they approach and/or penetrate the ground surface, and where they intersect aquifers and the waste dumps placed on the surface. The surface penetrations necessary to the operation of an underground mine at the Lamefoot site are the tunnel portals and the ventilation shaft collar. The potential exists at the Lamefoot site for subsidence to occur and to adversely impact the ground surface and the groundwater (see Section 4.1). However, mitigation (backfill) is proposed by Echo Bay to minimize that potential.

The Plan of Operations (Echo Bay 1993a) states that "[i]n order to minimize overall surface disturbance on public land and to prevent the possibility of subsidence of the rock overlying the open stopes, selective backfilling of the void produced during mining will be done after stoping is completed." Backfilling of the upper stopes will eliminate the possibility of collapse chimney subsidence (vertical rock fall directly from the roof or ceiling of the mine) breaching the surface, but not the development of trough subsidence at the ground surface due to the backfill using only to within 50 feet of the mine roof.

Trough (horizontal) subsidence develops over underground openings as the result of the deformation (which accompanies redistribution of the loads previously carried by the extracted waste rock and ore) of the rock over and adjacent to the openings. The magnitude of the trough subsidence over underground openings is dependent on the following factors:

- Size of the openings
- Depth of the openings
- Stresses present
- Properties of the rock present

Surface trough subsidence will be small over the planned near-surface Lamefoot stopes, because the elastic modulus of rock is high and the surface crown pillar should be able to support the mining-induced stresses, as indicated in the Plan of Operations, Appendix F, Addendum 2 (Echo Bay 1993a). The magnitude of trough subsidence will progressively increase in the case of progressive crown pillar failure, or chimneying, onto underlying backfill.

Boundary element modeling, computer impact modeling, which (approximates the geometry and geology of the planned stoping presented on Figures 10A, 10B, and 14, in the Plan of Operations) was performed to predict subsidence impacts utilizing realistic strain softening rock properties for the Lamefoot ore deposit. The program utilized was MULSIM/NL (Zipf 1992a). The physical property approximations used are presented in Appendix D, Table D-1. These were based largely on the Lamefoot data presented in the Plan of Operations. The dip of the Anfo Fault-controlled orebody was taken as 60 degrees. Figure D-1 in Appendix D presents: 1) the stope layout; 2) the contours of predicted stress normal to the plane of the orebody in the rock adjacent and between planned Anfo Fault stopes; and 3) the rock type distribution reported in the Plan of Operations. The rock type distribution was based principally on the Plan of Operations, with limestone (Pis) present in both the hanging wall and footwall of the southern third of the deposit, with a limestone hanging wall and clastics footwall (Pcl + Pls) in the central section of the deposit, and with clastics (Pcl) present in both the hanging wall and footwall of the northern third of the deposit. The two steeply dipping cross faults were taken from the stoping plans in the Plan of Operations.

The 3-dimensional plane of the vein modeling program used for this conservative approximation required a uniform stope width. It was assumed for the initial modeling calculation that the stopes will be 60 feet wide from hanging wall to footwall, somewhat greater than the average indicated in the cross section presented in the Plan of Operations. A second model was run approximating the maximum 130-foot mining width measured from the Addendum 2, Appendix F (Echo Bay 1993a) cross section. Boundary element modeling was performed for the following:

- Open, unfilled, stopes
- Conservatively assumed low-modulus backfilled stopes, approximating coarse rockfill without cement and
- Conservatively assumed high-modulus backfill, representing cemented coarse rockfill.

The backfill program proposed for the upper stopes; numbers 2, 3, and 4; is sufficient to eliminate any possibility of a collapse chimney breaching the overlying ground surface through the crown pillars. Appendix D presents the upper stope plan dimensions. The crown pillar thickness shown every hundred feet along strike for the planned upper stopes of the deposit, and the maximum allowable void height, are predicted to prevent chimney collapse from ever breaching the ground surface.

The effectiveness of the backfilling program in limiting the magnitude of trough subsidence of the surface will depend on the consolidation characteristics and effective modulus of the backfill actually employed. In the absence of backfill consolidation characteristics, it was necessary to utilize conservatively low backfill consolidation characteristics to predict trough subsidence magnitudes. Both the low-modulus and high-modulus backfills were approximated as bi-linear strain hardening materials. The initial 20 percent deformation of the low-modulus backfill was very conservatively assumed to proceed at 0.005×10^6 psi, and the remaining deformation at 0.02×10^6 psi. The initial 20 percent deformation of the high-modulus cemented backfill was very conservatively assumed to proceed at 0.05×10^6 psi and the remaining deformation at 0.2×10^6 psi. The results appear reasonable, based on the assumptions made and professional judgement. The results predicted are given on Table D-2 in Appendix D, and show the surface subsidence over: (1) open stopes without crown pillar failure; (2) stopes backfilled with loose uncemented rock fill; and (3) cemented rock filled stopes. Predicted subsidence varies from 0.95 inches in the 60-foot wide stope, to 1.68 inches in the 130-foot wide stope. Figure D-2 in Appendix D graphically presents stope closure for the stable open stope condition.

The subsidence-induced strains were conservatively predicted by assuming that (1) the stopes mined are approximately shown on Figures 10A and 10B of the Plan of Operations (Echo Bay 1993a); (2) the entire stope closure was transmitted undiminished through the overlying rock to the ground surface; and (3) any unfilled opening between the top of the backfill and the bottom of the crown pillar would be transmitted undiminished to the ground surface. Actual stope geometry will be controlled by cut-off grade determined by the economics at the time, in relation to the ore grade distribution. The proposed stopes represent current best estimates. The predicted surface subsidence values should exceed those eventually measured by the planned monitoring program, provided the assumptions required are conservative as intended. Similarly, the calculated ground surface strains represent local maximum values which should exceed the strains calculated from changes in the surface monitoring net.

Damage to the ground surface or to structures on the ground surface is primarily dependent on the surface strains developed. These strains are the result of flexure (turning or folding) accompanying surface subsidence centered over the stopes. The maximum surface strains are a function of the maximum surface subsidence and the depth. The maximum surface strains were calculated assuming stoping to within 50 feet of the ground surface, as shown on Figure 11 of the Plan of Operations, and stope widths of 60-foot and 130-foot and using the British National Coal Board (NCB 1975) subsidence prediction method. The results are presented in Table D-3 in Appendix D, in micro-strains.

The predicted maximum strains shown on Table D-3 are in the range that would result in the cracking of gypsum plaster, 1000 micro-strain (Voight and Pariseau 1970). As such, the maximum predicted surface strains resulting from trough subsidence should produce nearly undetectable cracking of joints exposed in rock outcrops, and should not be observable when soil cover is present.

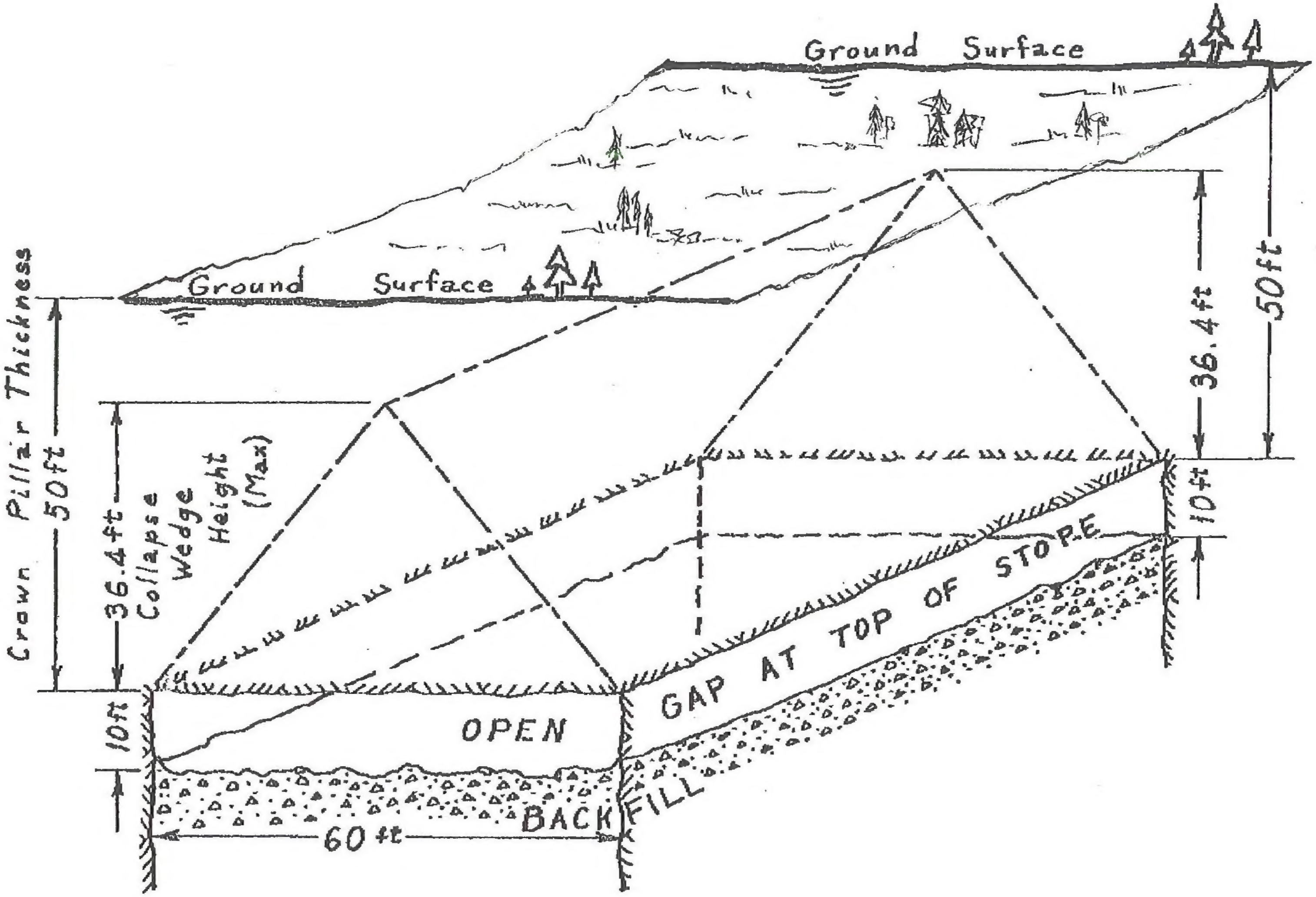
Tensile strain that develops horizontally along the outer sides of a subsidence trough will increase the permeability of the rock in the near-surface zone of rock subject to tensile strain (Wardell 1976; Kendorski et al. 1979; Moore and Nawrocki 1980). Babcock and Hooker (1977) presented guidelines for the calculated magnitude of tensile surface trough subsidence strain which would not result in surface water entering mine workings. They recommend limiting tensile surface strain to 0.00875 inch/inch. They reference British studies where calculated tensile strains of the overlying seabed were as much as 0.01500 inch/inch without sea water entering the workings. For Lamefoot, Table 4.4-1 presents the maximum opening (void height) for the upper Lamefoot stopes after backfilling to preclude surface subsidence. Figure 4.4-1 shows a schematic drawing of an example of worst case collapse of crown pillar into the stope under the conditions described in Table 4.4-1. Note that at no surface expression of subsidence results. Such openings should not result in any hydraulic communication between the ground surface and the near-surface stopes. Overall, with the above discussion in mind, impacts of the proposed action are rated low adverse.

4.4.3 Alternative Backfill Access

The potential environmental consequences during mining of the additional access drift is the possibility that groundwater moving down the intermittent Wolfe Camp drainage will be intercepted through fractures that may be present at that location (see Section 4.1). Since this possibility may exist, impacts are rated low to medium adverse.

4.4.4 Alternate Haul Routes

The alternate haul route presents no potential geologic or subsidence impacts.



CLIENT/PROJECT	ECHO BAY MINERALS Co. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON		TITLE PREDICTED CHIMNEY COLLAPSE GEOMETRY FOR EXAMPLE CASE LAMEFOOT PROJECT

TITLE	DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE:
				FEBRUARY, 1994			23295		4.4–1

TABLE 4.4-1

MAXIMUM VOID HEIGHT FOR PLANNED UPPER LAMEFOOT STOPES AFTER BACKFILLING

Stope (Zone)	Section	Crown Pillar Thickness	Maximum Allowable Void Height
2	N26000	83 feet	22.8 feet
	N26100	99 feet	27.2 feet
	N26200	114 feet	31.4 feet
	N26300	113 feet	31.1 feet
	N26400	113 feet	31.1 feet
3	N26500	64 feet	17.6 feet
	N26600	54 feet	14.9 feet
	N26700	50 feet	13.8 feet
	N26800	56 feet	15.4 feet
	N26900	50 feet	13.8 feet
	N27000	50 feet	13.8 feet
4	N27200	42 feet	11.6 feet
	N27300	100 feet	27.5 feet
	N27400	104 feet	28.6 feet
	N27500	150 feet	41.3 feet

4.4.5 Alternate Sub-County Road Backfill Access

The sub-county road backfill access alternative presents no potential geologic or subsidence impacts.

4.4.6 Limited Mine Development - 2750' Level

Under this alternative all stopes will be backfilled completely to the back in order to reduce subsidence and water inflow. For example, this could require using a mobile casting conveyor for the upper part of the final lift or use of a low-mobility slurry.

Adoption of this complete backfilling requirement will negligibly reduce the magnitude of trough subsidence and eliminate the long-term development of any chimneys in the planned crown pillars over Ore Zones 2, 3 and 4.

Table D-6, Appendix D, indicates the planned crown pillar thicknesses every 100 feet along Ore Zones 2, 3 and 4 and maximum allowable open (not backfilled) void heights at those locations to eliminate any possibility of chimney subsidence breaching the surface over Ore Zones 2, 3 and 4. Table D-7 presents the maximum height of long term chimney development with respect to void height at the top of Ore Zones 2, 3 and 4 and for equipment and personnel working conditions.

Table D-8 presents the maximum vertical surface trough subsidence of the ground surface at the maximum stope height locations over Ore Zones 2, 3 and 4 without backfill in the stopes and with backfill to limit the void at the back to the maximum height to prevent chimney subsidence to the ground surface. Table D-9 presents the maximum vertical surface trough subsidence of the ground surface at the maximum stope height locations over Ore Zones 2, 3 and 4 without backfill in the stopes and with complete backfill to the back to eliminate development of any chimney subsidence.

The trough subsidence reductions resulting from the limited mining alternative requirement for complete backfilling to the back of the stopes are negligible, essentially zero. The chimney subsidence reductions resulting from the limited mining alternative are significant because of the complete backfilling. However, these reductions would carry a progressively increasing cost to eliminate all chimney subsidence which does not appear to be justified because the strength of the rock types present at the top of the Lamefoot stopes, in conjunction with backfill, is more than adequate to support all anticipated stress concentrations in the crown pillars.

4.4.7 Limited Mine Development - 2,741' Level

This alternative presents the same subsidence impacts as those at the 2750' level.

4.4.8 Mill and Tailings

The expansion of the mill and tailings facility presents no potential geologic or subsidence impacts.

4.5 AESTHETIC RESOURCES

4.5.1 Impact Methodology

The assessment of visual resources was based upon methodologies described in the Visual Contrast Rating Handbook (U.S. BLM 1986b). Effects to visual resources were assessed for the operation and closure of the proposed mine.

The extent to which the proposed project would affect the visual resources depends on the amount of contrast created between the proposed action and the existing landscape elements (line, form, color and texture) and features (land, water, vegetation and structures). Assessing the impacts in this manner indicates the severity of the potential impacts and helps guide mitigation measures.

4.5.2 No Action

Under the No-Action Alternative, commercial mining operations would not occur, and the Lamefoot site would be reclaimed as outlined in the existing reclamation plan. No additional adverse impacts to visual resources would result from the No Action Alternative. The existing effects of the exploration activities would be mostly mitigated by successful reclamation of the site, which would include recontouring, covering and revegetating the waste rock stockpiles; reclamation of the exploration drill roads and pads; and removal of the support buildings and other structures. Under the current reclamation plan, some low to moderate, long-term adverse effects will remain on the site, including screen rock which may remain in some areas on the downhill side of the exploration drill roads and changes in the topography of the site left after the roads and waste rock stockpiles have been reclaimed. Revegetation of the area around the portal may be a long-term effort. Post-reclamation condition of the site would be within visual objectives for the project area.

4.5.3 Proposed Action

The proposed action would use open stope mining with backfilling. Surface disturbance associated with this alternative is primarily limited to the excavation of the hillside on the west side of Wolfe Camp Road, relocation of the Wolfe Camp Road, and additions to the waste rock stockpiles. The existing condition at the mine site includes structures, roads (exploration and access roads), waste rock stockpiles and a powerline which have introduced color and line contrasts in the landscape. With the proposed action, there may be a small increase in the height of the waste rock/ore stockpiles, which would increase the scale of the line, color and form contrasts created by the these facilities, but this would not be a significant increase in the contrasts created by existing site developments. The overall footprint of the stockpiles will not change. The increase in the height of the waste rock/ore stockpiles (estimated to be an increase of not more than 10 feet) would only occur during the first three months of commercial mining operations - after that initial time period the height of the stockpiles would return to their present levels or lower, as waste rock is removed for backfill (Echo Bay 1993c).

A more substantial increase in surface disturbance would be the excavation of the hillside west of the Wolfe Camp Road. An existing gravel pit exists within the site, but the proposed area of disturbance associated with the mine excavation would substantially enlarge the current area historic disturbance. An area along Wolfe Camp Road would basically become an industrial quarry site with occasional blasting, heavy equipment operation at the excavation site, road construction, and heavy cross traffic as trucks haul backfill from the excavation site across Wolfe Camp Road to the portal where the fill will be taken into the mine. This industrial activity would be visible to travellers on the Wolfe Camp Road for approximately one-half mile or about one minute at 30 mph. Blasting would necessitate the intermittent temporary closure of the Wolfe Camp Road, and would be scheduled to occur during low use periods.

Although proposed excavation activities would cause new areas of surface disturbance, the excavation site has been located and designed to be topographically screened from most observers, as the generally east facing slope is not visible to travellers along State Highway 21 or from most key observation points around Curlew Lake. Those most affected by the excavation along Wolfe Camp Road would be travellers on the road itself. Effects to these users would be substantial. There are five residences that use Wolfe Camp Road for access, and the road also receives light recreational and other use.

Another effect of the proposed action on aesthetics of the area is haul truck traffic. Truck traffic would leave the mine site, travel south along State Highway 21 until the Old Kettle Falls Road turnoff where it would head east on Old Kettle Falls Road, Jack Mays Pride Road and Fish Hatchery Road until arriving at the Key Mill. The presence of this industrial traffic would be noticeable, and noise would be generated as the trucks geared up and down as they were leaving or entering the mine site. There would be a low adverse impact to residences along the haul route as the increase in truck traffic would affect the aesthetics of their immediate environment. Noise may also be generated by other activities at the site including a crusher and waste rock/ore handling. Currently, noise generated at the site from various mine activities can occasionally be heard in the surrounding residential and recreational areas, although noise impacts are currently considered to be low. Noise impacts would increase under the proposed action.

Upon mine closure, areas to undergo reclamation include the waste rock stockpiles, the underground workings and associated surface facilities and any drill pads and access roads. Successful implementation of the reclamation plan will reduce most of the visual impacts associated with both exploration and mining, and will leave the area in a natural appearing condition compatible with the surrounding landscape. Activities associated with the commencement of mining operations at the Lamefoot site would be compatible with the VRM objectives for the project area.

4.5.4 Alternative Backfill Method

Trucks hauling backfill from the excavation site west of the Wolfe Camp Road to the mine workings east of the road would cause dust, noise and traffic impacts, as well as an additional visual impact to users of the county road. Removal of the haul truck traffic by the alternative backfill method would remove aesthetic impacts caused by this traffic. All other effects to aesthetics caused by quarrying operations, the relocation of the Wolfe Camp Road, and other components of the proposed action would remain the same.

4.5.5 Alternative Haul Route

The alternative haul route would use State Highway 21, and Fish Hatchery Road from its junction with the state highway to the mill site. For this alternative to take place, the Fish Hatchery Road may have to be paved and the road alignments straightened, causing short-term construction-related visual impacts to users of the road and residences along the route. All other impacts associated with haul traffic would remain the same under this alternative.

4.5.6 Alternate Sub-County Road Backfill Access

Dust and noise caused by trucks crossing the Wolfe Camp Road and accessing the portal on the east side of the road would be eliminated under this alternative. Other impacts to aesthetics caused by quarry operations, the relocation of the Wolfe Camp Road, and other components of the Proposed Action would remain the same (low to medium adverse).

4.5.7 Limited Mine Development - 2750' Level

Under this alternative, impacts to aesthetics would be the same as those of the Proposed Action during operations; however, the duration of the impacts would be reduced due to the shortened life of the mine.

4.5.8 Limited Mine Development - 2741' Level

Under this alternative, impacts to aesthetics would be the same as those of the Proposed Action during operations; however, the duration of the impacts would be reduced due to the shortened life of the mine.

4.5.9 Mill and Tailings

Associated with the startup of ore production at the Lamefoot mine is an expansion of the tailings facility at the Key Mill and an increase in milling activities. The current phase 1 tailings pond is a side valley impoundment with a capacity of 2.544 million tons. The phase 2 expansion, which was initiated in the summer of 1993, has resulted in the construction of a second pond located directly west of the existing (phase 1) pond and raising the perimeter embankment around both ponds. This will result in an increase in the scale and magnitude of the existing visible surface disturbance. The Key Mill and tailing ponds are not within the viewshed of any major highways or heavily populated residential areas, and effects to visual resources are considered low. Portions of the tailings pond and Key Mill are sporadically visible through the trees as hikers walk along the Kettle Crest Trail, located over 5 miles to the east. At this background distance impacts to trail users would also be low.

4.6 TRANSPORTATION

4.6.1 No Action

Under the No Action Alternative, impacts associated with excavation, hauling of backfill and ore, and the relocation of the Wolfe Camp Road would not occur. The talus rock above sections of the Wolfe Camp Road caused by exploration drill road construction would represent low, long-term adverse impact to the safety of travellers on the Wolfe Camp Road.

4.6.2 Proposed Action

The proposed action would involve transportation of ore from the mine site to the Key Mill. The primary haul route would utilize State Highway 21 between the Lamefoot Mine entrance to the Old Kettle Falls Road turnoff. Terrain along this section or highway is generally level, with grades and vertical alignments that would permit heavy trucks to maintain approximately the same speed as passenger cars. Trucks would travel east on Old Kettle Falls Road until Jack Mays Pride Road where traffic would turn north to the junction with Fish Hatchery Road. Haul trucks would travel east on Fish Hatchery Road to the Key Mill. A few grades exist along portions of the county roads that would cause heavy trucks to reduce speeds below that of most passenger cars. This route would involve approximately 5 miles of State Highway 21 and 3.8 miles of county roads. Figure 1-2 shows the proposed and alternative haul routes.

During commercial ore production, ore haulage will range from thirty to seventy round trips per day depending on truck size and production rates. This equates to an increase in Average Daily Traffic (ADT) of 60 to 140 vehicles. Ore hauling will take place 12 hours a day, between 6:30 AM and 6:30 PM, seven days a week, which would mean that at any point along the route 5 to 12 trucks would pass by per hour.

The increase in heavy truck traffic will be noticeable to residents along the route and to travellers along the highways. The smaller county roads will experience a proportionally greater increase in traffic than the state highway. ADT for the section of State Highway 21 between Wolfe Camp Road and Old Kettle Falls Road is approximately 1,420. An increase of 60 to 140 ADT would represent a 4.2 to 9.9 percent increase — to 1,480 to 1,560 ADT — which would still be within the capacity of the highway. Impacts will include an increase in dust, noise and an increase in road surface deterioration.

An increase in traffic may also increase the accident rate, and the severity of the accidents, considering the heavy trucks involved. Based on the existing accident rate on this section of State Highway 21 of 3.48 accidents per year, and assuming that accident rates are directly relational to the amount of traffic, the accident rate could also increase 4 to 9.5 percent, from 3.48 accidents per year to 3.62 or 3.81 accidents per year.

Periods of weight restrictions and/or construction on State Highway 21 would change the description of haul traffic. Prior to weight restrictions going into effect, ore hauling may increase in order to stockpile ore at the mill. Haul traffic may exceed the 60 to 140 ADT occurring under normal operating conditions. During periods of road construction, which are scheduled to occur in 1995, some hauling may take place at night in order to avoid traffic delays. Hauling would remain within the 60 to 140 ADT range during these periods. Periods of increased haul traffic prior to weight restrictions would cause an accompanying increase in noise, dust, and road deterioration. Night hauling during construction periods on the state highway may cause noise impacts to residences along the route during the night. Impacts to State Highway 21 are rated medium to high adverse.

The Wolfe Camp Road will also be affected by the proposed action. As discussed in Section 3.6.3.2, a section of Wolfe Camp Road would be relocated west from its present alignment. Users of this road could experience construction delays and would have to pass through an intersection with an Echo Bay road which would be used for hauling backfill material from the excavation site to the mine. The road environment would change from one that is now a small, lightly used county road to a road that passes through an industrial quarry site including a gravel pit and heavy truck traffic. This type of environment would exist for approximately one-quarter to one-half mile. Effects to users of the road would include increased dust, noise and cross traffic. Traffic on the county road would not have to stop at the intersection, as stop signs will be located along the crossroad. The introduction of an intersection could increase the traffic hazard. Impacts are rated medium adverse.

The Old Kettle Falls Road, Jack Mays Pride Road and the Fish Hatchery Road would experience an increase in traffic and associated dust, noise and, for the graveled roads (Jack Mays Pride Road and Fish Hatchery Road), an increase in rutting or washboarding of the road surface. However, existing maintenance agreements with the County for these road segments, and payments of license fees and fuel taxes to support state highway maintenance, are committed by Echo Bay, and will mitigate these impacts to some extent. Overall, the impacts are rated low to medium adverse.

4.6.3 Alternate Backfill Method

This alternative would move backfill from the excavation area on the west side of Wolfe Camp Road to the mine workings via an underground tunnel, thereby eliminating the need for surface transport of backfill material. Haul trucks would not cross the Wolfe Camp Road, which would remove traffic hazards that may be created as a result of the intersection of the haul route with the county road. Dust and noise generated by the haul trucks would also be eliminated, although any dust and noise resulting from the quarry operations would remain. The relocation of the Wolfe Camp Road would still be part of the proposed action, and all other effects to transportation would be the same as identified in the analysis of the proposed action, Section 4.6.1.

4.6.4 Alternative Haul Route

The alternative route would use State Highway 21 and Fish Hatchery Road. This route would be shorter than the proposed action, would reduce effects to the state highway and save fuel costs. Effects to the Old Kettle Falls Road and Jack Mays Pride Road from haul traffic would be removed. Impacts such as dust, noise and increased truck traffic would occur on Fish Hatchery Road. Fish Hatchery Road would require substantial upgrading to be used by ore haul trucks, causing an increase in road maintenance and construction costs, and cause impacts related to road construction such as traffic delays, dust and noise.

4.6.5 Alternate Sub-County Road Backfill Access

Under this alternative, backfill would be hauled by truck from the backfill borrow area, located on the west side of the Wolfe Camp Road, to the underground mine workings on the east side of the road, via a portal located under the Wolfe Camp Road. Trucks hauling backfill would be loaded at the borrow area and drive into the portal entrance without crossing the Wolfe Camp Road, which would eliminate traffic safety and control concerns associated with the intersection of a portal access road and traffic on the county road. The portal entry would be a 15 foot wide, 18 foot deep open cut through the Wolfe Camp Road, covered with a steel and concrete roof. The Wolfe Camp Road would be constructed over the portal entrance. Construction of the portal and reconstruction of the county road would require the temporary rerouting of the Wolfe Camp Road for approximately two to three weeks along an existing drill road in the valley bottom.

Dust and noise from trucks hauling backfill would be reduced from the Proposed Action, although dust and noise generated from the quarry operations would remain. Traffic safety along the Wolfe Camp Road would be significantly improved from the Proposed Action. Other effects to transportation resources would be the same as the Proposed Action. In sum, impacts to transportation would be less than the Proposed Action, and about the same as the alternative drop pass backfill access Alternative 2 (or low to medium adverse).

4.6.6 Limited Mine Development - 2750' Level

Transportation impacts would be similar to the proposed action, medium adverse during operations; however, the duration of the impacts would be reduced due to the shortened life of the mine.

4.6.7 Limited Mine Development - 2741' Level

Transportation impacts would be similar to the proposed action, medium adverse during operations; however, the duration of the impacts would be reduced due to the shortened life of the mine.

4.6.8 Mill and Tailings

The continued use of the mill and the enlargement of the tailings pond would not appreciably affect transportation resources. Traffic from the Key Mill (other than ore haul trucks which has been addressed in the proposed action section) is primarily limited to employee and service vehicles and averages about 35 personal vehicles (70 employees at 2 people per vehicle) and 10-20 service vehicles per day. Most mill traffic comes north from the junction of State Highway 20 and State Highway 21 to the Old Kettle Falls Road, east to the Jack Mays Pride Road and Fish Hatchery Road. Impacts to transportation from mill and tailings traffic is rated as low adverse.

4.7 NOISE

As background to the noise impacts discussion, it should be noted that such impacts would be classified as high and adverse if implementation of the Lamefoot commercial phase would result in violation of applicable state noise standards presented in Section 3.7. It is also noted that noise at other mining projects in the region has been effectively controlled through implementation of various common control measures. Although the potential does exist for increases in noise levels as a result from the proposed mining project or alternatives, the likelihood for a significant noise impact due to the proposed Lamefoot project would appear to be slight as shown with noise level monitoring data collected at the site during spring, 1993.

Although blasting in support of mining activities is exempt from regulation during the hours of 7 a.m. to 10 p.m., blasting events may produce a significant noise level during the few seconds of the event. However, when this event is considered over an hour period, the resultant noise level would still be lower than the Washington State allowable limit of 60 dBA.

4.7.1 No Action

If the No Action Alternative prevailed, then noise levels would return to those levels in natural environments such as the study area after reclamation. Reclamation activities at the site would involve heavy machinery which would be involved in structure removal, grading, and recontouring of land surfaces. These temporary noise sources should not exceed the State of Washington maximum allowable environmental noise levels, and thus would result in a low, adverse impact to noise levels. The resultant natural environment noise levels may then range from 15 decibels (dBA) up to 45 or 50 dBA, depending upon the naturally occurring noise sources, with a no adverse noise impact rating.

4.7.2 Proposed Action

In general, noise-producing activities associated with operation of the Lamefoot Project would be those typical of any similar mining project. The major noise sources would include the operation of heavy equipment, haul trucks and light vehicles. Compressors, intermittent blasting, and ventilator fans would also contribute to the noise levels as a result of the commercial mining project. As discussed in Section 3.7, the noise levels generated from mining activities at the surface would be noticeable beyond the study area boundaries sometime and other times would blend with natural background noises. Ventilation fans and compressors associated with underground mines can be irritatingly loud without means of noise attenuation sufficient to adequately absorb fan noise to acceptable level. The increase in truck traffic and activity associated with loading the trucks would result in additional noise.

As shown in the noise survey, highway noise increase over a typical and quiet receiver location, such as the dwellings on the west side (40.0 dBA) of Curlew Lake, is about 3.1 dBA (to 43.1 dBA), and the increase from Lamefoot activities is about 8.8 dBA to 48.8 dBA). The site-specific noise monitoring illustrates that no daytime or nighttime 15 minute average sound level exceeded the DOE noise standards.

During the commercial mining phase, many noise impacts would be mitigated to a greater extent than during the exploration stage when the noise survey took place. A number of mitigation measures have been implemented to decrease the impacts of noise at the Lamefoot site during the exploration stage. Where practical, drill rigs have been muffled or enclosed. The compressor for the mine has been enclosed in an insulated building. The exhaust from this building is baffled. Fans installed outside of the portal were muffled at the intake and outlet ends. Further mitigation of this noise source was introduced when the fans were moved underground for further mitigation and elimination of their whine.

Modifications have been made to the ventilation raise specifically to address the noise issue. The noise survey showed that the ventilation raise was a source of background noise. A wall would be placed outside of the exhaust portal to deflect upwards any noise from underground.

Fast-growing poplar trees have been planted on top of the growth medium storage berms to help mitigate noise impacts over the long term. Along with the berm itself, they may be effective in reducing the impact of some site noise, especially in the summer months when leaves are out and when neighboring residences may have open windows.

The front end loader (which loads ore on the haul trucks) has a high noise level backup alarm, which is required by the Mine Safety and Health Administration (MSHA). During nighttime operations, the alarm will be replaced by strobes.

With these mitigation measures in mind, impacts from proposed action mining are rated low adverse.

4.7.3 Alternative Backfill

Alternate backfilling uses shafts to provide access to the mine would decrease the amount of traffic on the surface, thereby lessening noise levels in the Wolfe Camp Valley.

4.7.4 Alternative Haul Route

Both the alternate route and the proposed route utilize the existing Highway 21, with insignificant increases in noise levels. It is estimated that noise levels would be equivalent for these two routes, or low adverse.

4.7.5 Alternate Sub-County Road Backfill Access

Noise impacts from the Sub-County Road Backfill Access Alternative will be very similar to those for the Proposed Action (low adverse), as most noise generating activities will not change. A slight reduction in truck traffic noise may result from the elimination of the Wolfe Camp Road intersection, as haul trucks will no longer be required to stop and start up at the intersection and can proceed directly into the access drifts.

4.7.6 Limited Mine Development - 2750' Level

Noise impacts would be the same as those for the Proposed Action, low adverse during operations; however the duration of the impacts would be reduced due to the shortened life of the mine.

4.7.7 Limited Mine Development - 2741' Level

Noise impacts would be the same as those for the Proposed Action, low adverse during operations; however the duration of the impacts would be reduced due to the shortened life of the mine.

4.7.8 Mill and Tailings

Most noise producing ore processing activities here, with the exception of the tailings pond, occur within enclosed structures. Thus, these potential noise levels are adequately mitigated. Noise levels would be comparable to those previous noise levels associated with processing the Key East and Key West ores. Overall, impacts are rated low adverse.

4.8 SOILS AND RECLAMATION POTENTIAL

4.8.1 No Action

Past implementation of exploration activities has resulted in the disturbance and alteration of in-place, natural soils. Adverse impacts to native soils have resulted from the clearing of protective vegetation, the excavation and storage of coversoil materials (including topsoil and suitable subsoil), the exposure of disturbed soil materials to wind and water erosion, and the loss of soil productivity in areas replaced by exploration facilities including drill sites, access roads, portal, and supporting facilities. Probable direct adverse effects on soils that have resulted from implementation of the exploration and related facilities/ activities include the following:

- Loss of pedogenic (soil) development, including soil structure and distinct soil horizons
- Loss of soil material due to increased rates of erosion

- Alteration of biological and nutrient conditions in topsoil materials stored in piles for extended periods

- Compaction of soil materials beneath facilities and in areas of natural soils crossed by vehicular traffic

- Loss or reduction of soil productivity

Previous excavation, transportation, and construction of coversoil material stockpiles will likely have effected the breakdown of soil aggregates into loose soil particles, and increased the potential for wind and water erosion on the stockpiles. Storage of topsoil materials can further aggravate the breakdown of natural aggregates and alter the favorable nutrient and microbiotic condition commonly present in topsoil. Measures to stabilize and protect topsoil stockpiles are described in a Reclamation Plan (Appendix E). These measures have been or will be implemented to control soil loss and prevent additional disturbance to stockpiled coversoil.

Under the No Action Alternative, further actions including additional disturbances of soils would cease and final reclamation measures would be initiated as seasonal constraints permit. Reclamation activities would follow those defined in the Reclamation Plan for the project area presented in Appendix E. Portals, ventilation openings, and boreholes would be sealed; structures would be removed; disturbed areas would be backfilled/graded/recontoured (including the waste rock piles) and ripped as necessary; coversoil would be redistributed drill sites; and all disturbed areas would be revegetated. During the reclamation process, soils would be temporarily exposed to forces of erosion; however, moderate to high impacts in the form of accelerated losses of soil material would be short-term, as reclamation measures would soon be implemented to control any excessive soil loss. Overall, impacts are rated low adverse.

Stockpiled coversoil material volumes available for reclamation of areas disturbed during exploration total 8,847 cubic yards (238,865 cubic feet). This volume is sufficient to cover the approximately 27 acres of existing disturbance on private and federal lands with approximately 2.5 inches of coversoil.

4.8.2 Proposed Action

Implementation of underground open stope mining operations would disturb approximately 17-18 acres of private land for the purpose of providing supplemental rock for backfilling the mined-out underground mine workings. Of the 18-acres of proposed disturbance, approximately 10.0 acres would be new disturbance; 8.0 acres has been previously disturbed by quarry operations. Approximately 10.0 acres of existing soils would be affected. Of the 10.0 acres approximately 6.6 acres are mapped as the Molson-Rock land soil complex (MyE) and the remaining 3.4 acres are mapped as Colluvial Land (Cu), which consists mostly of rocky, talus material. Based on a 60 percent soil-component composition of the Molson-Rock land unit (USDA SCS 1979a), approximately 4.0 acres of soils are available for salvage.

Any additional disturbance on federal lands would be expected to be less than 5 acres for the life of the project. Appropriate permitting requirements will be met prior to any such disturbance.

Adverse impacts to Molson soils not previously disturbed by prior quarry activities would be similar to those moderate to high level of impacts described in Section 4.8.1 for exploration activities. Protective vegetative cover would be removed; soil materials would be removed to expose the rock substrate for quarrying. Suitable coversoil material for use in reclamation would be salvaged and placed in protected, stabilized coversoil stockpile. Exposed subsoil and rock materials left after coversoil salvage will be quarried for mined-stope backfill. Accelerated erosion and drainage bottom sedimentation would occur until the remaining unconsolidated soil materials are removed from mine backfill.

Salvage of all suitable coversoil material to a depth of 28 inches (Table 3.8-1) would yield an estimated 14,843 cubic yards (400,761 cubic feet) of coversoil material for use in reclamation. With the addition of this new volume of coversoil material, the total stockpiled coversoil resource would total 27,412 cubic yards (740,124 cubic feet). This volume of coversoil material would cover the approximately 27 acres of disturbance to be reclaimed, as associated with the Lamefoot Project, with a 7.5-inch layer of coversoil. The 18-acre rock backfill quarry would be quarried in terraced lifts so as to leave a stable, terraced rock slope without a cover of soil.

Additional adverse impacts which could result from proposed mine operations include potential soil contamination from releases or spills of fuels, lubricants, or solvents related to vehicle maintenance and operation. Backfilling of the mined stopes using waste rock would result in the removal of the waste rock piles and exposure of soils formerly buried beneath the piles. Should the waste rock have produced acidic drainage or leachate, the underlying soils could become acidic, and contaminated with introduced and newly released metals. Overall, proposed action impacts are rated low adverse.

4.8.3 Alternative Backfill

The alternative backfill procedure would have the same impacts on soils and reclamation potential as the proposed action (see Section 4.8.2).

4.8.4 Alternative Haul Route

Use of the alternative haul route would result in no additional soil disturbance beyond that described for the proposed action (see Section 4.8.2).

4.8.5 Alternate Sub-County Road Backfill Access

The sub-county road backfill access alternative would have the same impacts on soils and reclamation potential as the proposed action (see Section 4.8.2).

4.8.6 Limited Mine Development - 2750' Level

Use of this alternative would result in the same impacts to soils and reclamation potential as the proposed action.

4.8.7 Limited Mine Development - 2741' Level

Use of this alternative would result in the same impacts to soils and reclamation potential as the proposed action.

4.8.8 Mill and Tailing Disposal Facilities

As discussed in Section 4.8.1, new impacts to soils associated with the mill and tailing disposal facility would occur during reclamation of these facilities. The moderate to high but short-term effects would be similar to those previously described in Section 4.8.1. No additional soil disturbance due to facilities construction in Phase IIA is proposed. Five to ten acres of new disturbance would be associated with the Phase IIB tailings expansion, resulting in topsoil removal and temporary reduction in the average of native grasses and sparse ponderosa pine currently present here.

4.9 AIR RESOURCES

As background to this discussion, air quality impacts would be classified as significant (or high adverse) if and when implementation of the Lamefoot operational phase would result in violation of applicable state and/or federal air quality standards, as presented in Section 3.9. Dust and vehicle exhaust would be the only substantial air quality concerns generated by the proposed Lamefoot Project, or subsequent alternatives considered. Dust at other mining projects in the region has been effectively controlled through implementation of various common dust control measures. Although the potential does exist for some adverse air quality impacts to result from the proposed mining project and alternatives, the likelihood for a major problem at Lamefoot would appear to be slight, if the proposed action is implemented.

4.9.1 No Action

If the No Action Alternative prevailed, then ambient air quality levels would return to those levels in natural environments such as the study area after reclamation. Reclamation activities at the site would involve heavy machinery which would be involved in structure removal, grading, and recontouring of land surfaces. These temporary sources would generate dust, but would not exceed the ambient air quality standards.

4.9.2 Proposed Action

The air quality emissions inventory (which evaluates dust and combustion engine emissions from mining equipment, haul trucks, and support vehicles) is summarized in the Lamefoot Plan of Operations (Echo Bay 1993a), and is fully documented in the Air Emissions Permit Document (TRC 1993). Table 4.9-1 presents the summary of air emission rates (uncontrolled and controlled for dust) from the Lamefoot Mine, from the various Kettle River Project components, and from the other two industrial facilities in the Republic Area, including the Hecla Knob Hill Mine, and the Vaagen Brothers lumber mill.

No air dispersion modeling to predict air pollution concentrations from the proposed facilities has been conducted. Thus, a comparison to ambient air quality standards cannot be performed.

The steps in the mining process that affect air emissions include rock drilling, blasting, rock loading, underground hauling, dumping and reloading, hauling to the mill, use of dozers, graders and miscellaneous equipment in these processes, and wind erosion of exposed areas and ore and waste rock piles. Emissions associated with a crusher to size material for the cemented backfill plant have not been quantified. Neither the schedule of use (which would not be continuous) nor location (which would vary) can be determined because these items depend on mining cycles within the backfill excavation. Nevertheless, BACT (Best Available Control Technology) will be applied to these emission sources, and impacts will be negligible (very low adverse) compared to the other emission sources. The dust abatement plan, as discussed in Section 2.0, includes application of dust control water sprays to haul roads and a water spray dust suppression system integrated within the mine ventilation system.

Equipment and vehicle emission are not expected to exceed DOE standards during Lamefoot operations. Thus, no active emissions mitigation is warranted. However, Echo Bay has committed to employ best management practices in maintaining all equipment and vehicles at optimum performance levels by adhering to strict maintenance and repair schedule. BACT proposed for fugitive dust sources includes the application of dust control water sprays or dust suppressant (lignate sulfate) to the haul roads, and misting of ventilation borehole exhaust. Overall, impacts to air resources are rated low adverse.

TABLE 4.9-1

AIR QUALITY SUMMARY OF EMISSIONS

Kettle River Project Component	Fugitive Dust (ton/year)				SO_x (tons/year)	NO_x (tons/year)	CO (tons/year)	HC (tons/year)
	Uncontrolled		Controlled					
	TSP	PM_{10}	TSP	PM_{10}				
Vaagen Bros. Lumber Mill	41.6	NA	NA	NA	2.26	11.43	198.45	2.84
Hecla Knob Hill Mine	0.67	NA	NA	NA	0.26*	0.04*	0.18*	0.01
Kettle River Mine 1988-1992	3.2	NA	NA	NA	0.1	2.8	1.2	0.4
Overlook Mine 1988-1992	4.6	NA	NA	NA	0.2	2.4	1.1	0.4
Key East & West Mines 1993	129.0	NA	NA	NA	30.0	291.0	143.0	16.0
Key Mill & Tailings Facility 1993	265.0	61.0	87.9	27.7	0.6	6.4	1.8	0.7
Lamefoot Mine 1993	51.5	17.5	NA	NA	24.1	223.9	72.3	11.9
Kettle River Project Totals	453.3	NA	NA	NA	55.0	526.5	219.4	29.4
Lamefoot Percent of Total	11.4%				2.3%	42.5%	33.0%	40.5%

Notes: NA - Not available.

Sources: TRC 1993; WDE 1988; DOE 1993; Ryan 1993.

* Note: Gaseous emission rates for Hecla Boiler is not available.

4.9.3 Alternative Backfill

Alternate backfilling would reroute haul truck traffic from the mine portal to the road underground. Increase of off-property ambient air quality would depend on schedule of operation and final location of the crusher. Nevertheless, the increase in ambient air quality levels on site and in the surrounding environs should not exceed the ambient air quality levels. Impacts to air resources are rated low adverse.

4.9.4 Alternative Haul Route

While the proposed action involves a longer route, fugitive dust emissions would be greater on the alternative haul route, because the alternative includes haul road traffic on a longer stretch of unpaved roadway. Mitigative measures to control air pollution emissions discussed under the proposed action section above would be employed. If the alternative route were paved and used (a likely scenario), emissions would be slightly less, still low adverse. Vehicle exhaust emissions would also be lower.

4.9.5 Alternate Sub-County Road Backfill Access

The Sub-County Road Backfill access alternative will not significantly change the air quality impacts resulting from the Proposed Action (low adverse), as the activities producing air emissions will not change. A slight reduction in truck traffic emissions may result from the elimination of the Wolfe Camp Road intersection as haul trucks will no longer be required to stop and start up at the intersection.

4.9.6 Limited Mine Development - 2750' Level

Air quality impacts from this alternative would be the same as those for the Proposed Action, low adverse during operations; however, duration of the impacts would be reduced due to the shortened life of the mine.

4.9.7 Limited Mine Development - 2741' Level

Air quality impacts from this alternative would be the same as those for the Proposed Action, low adverse during operations; however, the duration of the impacts would be reduced due to the shortened life of the mine.

4.9.8 Mill and Tailings

A summary of annual gaseous and fugitive dust emission rates are presented in Table 4.9-1. In addition to dust emissions from transportation, potential releases of particulate matter would be made from the ore stock piles, crusher buildings, and exposed beach areas at the tailings impoundment. BACT has been applied to the mill and tailings compound through a program of as-needed water application and/or chemical stabilization on road surfaces and exposed areas during the operational phase. Particulate emissions from conveyer systems in the crusher complex are controlled through the use of enclosed transfer points. Tailings are distributed in a manner that the surface of the impoundment remains wet during most times of the year. As shown in Table 4.9-1, TSP emissions are controlled 301 percent, while PM10 emissions are controlled by 220 percent. Overall, impacts to air resources here are rated low adverse.

4.10 RECREATION

4.10.1 Impact Methodology

Direct effects to recreational resources would occur if the proposed project resulted in the termination of use, or modification of recreational resources within the study area. Indirect effects would occur if operational activities affected recreation use patterns, recreation demand, the recreational environment, or access to recreational use areas.

4.10.2 No Action

Under the No Action Alternative, there would be no commercial mining, and reclamation of the Lamefoot site would take place as outlined in the existing reclamation plan. Impacts to recreation resources due to commercial mining activities, which are considered to be primarily related to visual and noise impacts, would not occur. Some temporary noise impacts would affect Curlew Lake State Park during reclamation, but these impacts would be considered minor.

4.10.3 Proposed Action

The proposed action would cause no direct impacts to recreational resources. Indirect impacts are generally limited to visual and noise effects caused by the project. Dispersed recreational activities occurring on the Colville National Forest east of the project site are generally out of the line of sight of most mine activities, and impacts would be considered low. Recreationists at the campgrounds, picnic areas, or boat launch facilities at Curlew Lake State Park are shielded by topography from views of most mine activities. The park received 81,407 visitors in 1992, a year in which exploration activities were taking place, but the park reports receiving only a few comments on the mining activities, primarily related to noise coming from the mine at night. Waste rock/ore handling, rock crushing, occasional blasting, and haul truck traffic will generate additional noise which would be heard from the state park and from other areas on and around the lake. Noise impacts to recreationists on and around the lake may increase. Impacts are rated as moderate adverse: the intensity of the impact will depend on the specific location of the receptors, and the mine activity in progress.

Recreationists using the Wolfe Camp Road for access will occasionally be impacted by the visual and noise effects caused by the road relocation and excavation activities. Recreationists using State Highway 21, Old Kettle Falls Road, or Fish Hatchery Road for access to recreation areas will experience an increase in heavy truck traffic along these routes. This would not be expected to significantly affect their overall recreational enjoyment. These low, adverse impacts would last for the life of the project. The cessation of mining activities and successful reclamation will return the area to a condition compatible with the surrounding recreational environment.

4.10.4 Alternative Backfill Method

The alternative backfill method would not appreciably affect the type or amount of impacts to recreation resources.

4.10.5 Alternative Haul Route

There would be no substantial difference in impacts to recreational resources from the alternative haul route.

4.10.6 Alternate Sub-County Road Backfill Access

Impacts to recreation resources would not be appreciably changed by an alternative method of delivering backfill to the underground mine workings, and remain medium/high adverse for Curlew Lake State Park, and low adverse for other recreation.

4.10.7 Limited Mine Development - 2750' Level

There would be no substantial difference in impacts to recreational resources from this mining alternative during operations; however the duration of the impacts would be reduced due to the shortened life of the mine.

4.10.8 Limited Mine Development - 2741' Level

There would be no substantial difference in impacts to recreational resources from this mining alternative during operations; however the duration of the impacts would be reduced due to the shortened life of the mine.

4.10.9 Mill and Tailings

Commercial mining at the Lamefoot Mine would increase activity at the Key Mill and is a factor in the expansion of the tailing ponds. This activity would have no appreciable effect on recreation resources in the area. Users of the Kettle Crest Trail occasionally have views of the mill and tailings area, but any effects to the recreational environment along the trail are very low, considering the distance of the trail from the facilities.

4.11 SOCIOECONOMICS

4.11.1 No Action

The No Action Alternative would result in high adverse socioeconomic impacts due to reduced direct and indirect employment, earnings, and tax revenues in the study area. As described subsequently in Sections 4.11.2, 4.11.5, and 4.15.11, the Proposed Action would both create new jobs at the Lamefoot Mine and Key Mill and maintain existing jobs at the Lamefoot Mine, Key Mill, and the Echo Bay Kettle River operations office. Under the No Action Alternative, the Lamefoot exploration program would cease and the mine would be closed. Moreover, the Key Mill and Kettle River operations office would no longer be viable and would also likely close. The following discussion describes the employment, earnings, and tax revenue impacts associated with the No Action Alternative.

4.11.1.1 Employment and Earnings

In terms of direct Echo Bay employment, the No Action Alternative would result in both the loss of existing jobs and earnings, and elimination of new jobs that would be created under the Proposed Action. At present, 35 workers are employed at the Lamefoot Mine, 36 are employed at the Key Mill, and 30 are employed at the Kettle River operations office. Since the Lamefoot exploration program would cease and Echo Bay's Kettle River operations would likely no longer be viable, all 101 positions could be eliminated. Terminated workers would have to leave the study area for employment alternatives elsewhere, or find new jobs locally. The loss of 101 existing jobs would result in the loss of approximately $4,344,000 in earnings per year for six years.

Similarly, 33 new jobs proposed at the Lamefoot Mine and 7 new jobs proposed for the Key Mill under the Proposed Action would not be created. These 40 positions would account for roughly $1,720,500 per year in earnings that would not be generated. In total, direct employment losses would be 141 positions, with total lost earnings of $6,064,500 per year. Such losses would constitute a high adverse impact to the economy of Ferry County.

In terms of lost indirect employment and earnings, based on a multiplier effect of 1.5, approximately 211 jobs in the service and retail sectors would be lost, with associated yearly earnings of $2,432,000. This would also constitute a high adverse impact to the local economy, considering the total employment in Ferry County (City of Republic 1993b) is approximately 2,550 jobs (approaching a 10% loss on total County employment). Similarly, purchases of goods and services by Echo Bay for the Lamefoot Mine and Key Mill would not occur, thereby exacerbating the loss of economic activity in the service and retail sectors.

4.11.1.2 Tax Revenue Generation

The No Action Alternative would result in high adverse impacts to tax revenue generation due to the elimination of 141 positions at Echo Bay and associated loss of payroll, sales, ad valorem, and business opportunities and taxes. The total of these taxes amounted to $3,440,000 in 1992 (Echo Bay 1993c). The direct tax revenues that would be generated by Echo Bay in the future under the Proposed Action would be comparable, and would not be realized under the No Action project scenario.

In addition to loss of direct tax revenue by the City of Republic, Ferry County, and State of Washington, the loss of mining employment under the No Action alternative would represent a contraction of the local tax base, resulting in increased pressure on a smaller number of tax payers to cover government service expenses, such as schools and roads.

As an example, the loss of mining activity and reduced tax base would make it far more difficult for Ferry County to issue bonds to finance needed school construction and improvements. To cover the cost of needed services and improvements, property tax rates would have to be increased on County residents (Sweetman 1993).

4.11.1.3 Social Effects

Social effects of the No Action Alternative are difficult to predict. Depending on one's values, elimination of the mine-related employees and their families could have medium to high adverse or beneficial impacts on the social fabric of Ferry County. For individuals who prefer the status quo, this Alternative would have medium to high adverse effects. For those who would rather see the local economy convert to tourism, recreation, and retirement, this alternative would result in medium to high beneficial impacts. With the departure of mine-related employees or families, other jobs (and persons) would be affected. Families that earn their livelihood from mining in the project area would encounter hardship due to loss of jobs and earnings; unemployed miners and their families would likely leave the project area, or change occupations to remain. The current balance of timber, agriculture, mining and recreation in the county would be substantially affected. The burden of electrical rates would shift to residential users. In addition, a correlation between the local unemployment rate and the incidence of crime has been suggested, based on recent statistical data (Sweetman 1993; Ennis 1993). If such a correlation were to remain valid in the future, the crime rate would likely increase in the project area due an almost certain increase in unemployment under the No Action alternative. This would constitute a medium adverse impact on the social fabric of Ferry County.

Impacts to other socioeconomic issues such as housing and local government services (fire, public emergency services, health care) were assessed in earlier documents on the project (USFS 1992; Echo Bay 1993a) and are likely to be little affected.

4.11.2 Proposed Action

The Proposed Action would have direct and indirect beneficial impacts on employment and earnings in the socioeconomic study area. Direct beneficial impacts would include both increased employment at the Lamefoot Mine and perhaps more importantly continued employment at Echo Bay's Key Mill and Kettle River administrative office. As a result of these direct employment impacts, the Proposed Action would also result in indirect beneficial impacts on service and retail sector employment, due to the multiplier effect.

Finally, the Proposed Action would result in the continued generation of substantial tax revenues for the state and local governments. The following sections provide a detailed description of these impacts.

4.11.2.1 Population

Study area population would not change appreciably as a result of the Proposed Action. New jobs that would be created would generally be filled by current residents of the study area that were laid-off from other mining operations in the past. Thus, no significant influx of new workers and their families is predicted to occur as a result of the Proposed Action, and no notable population-related impact would likely occur.

4.11.2.2 Employment and Earnings

Implementation of the Proposed Action would create approximately 33 new jobs at the Lamefoot Mine, in addition to the 35 jobs that currently exist under the exploration program. These 33 new jobs would generate approximately $1,419,400 in earnings annually, resulting in a high beneficial impacts. The Proposed Action would also result in the continued employment of the 35 exploration workers, with associated annual earnings of $1,505,000, for roughly six years. Employment and earnings would then drop during the reclamation phase to roughly 15 positions, with associated earnings of $645,000 in 1994 dollars. Thus, the project's creation of 68 mining jobs would help to offset the loss of approximately 103 mining jobs that occurred in 1992 and 1993 due to closure of the Overlook, Key East, and Key West mines. As mentioned previously, the Proposed Action would also assure continued operation of the Key Mill and Echo Bay's Kettle River Operations administrative office. Impacts associated with the Key Mill are described subsequently in Section 4.11.7; the impacts associated with continued operation of the Echo Bay Kettle River Operations office are described in Section 4.15.11.

Indirect Economic Activity Stimulated by the Proposed Action

The creation of 33 new and the maintenance of 35 existing mining jobs at the Lamefoot Mine, and the associated generation of earnings, would indirectly create and maintain jobs in the retail and service sectors within the study area. Based on a multiplier of 1.5, the Proposed Action would result in the indirect employment of approximately 102 workers, with earnings of approximately $1,176,000 annually. This creation of indirect employment and earnings would be a high beneficial impact.

Similarly, implementation of the Proposed Action would result in purchases of inputs (goods and services) for the Lamefoot Mine, such as electric power and supplies, that would also stimulate the local economy over the life of the project. As a specific example, electric power purchases would amount to approximately $210,000 annually.

Over time, the productive life of the Lamefoot Mine would end. As a result, the beneficial impacts of direct and indirect employment and earnings would end. Without the creation of new mining employment elsewhere, the number of mining jobs would decline. Based on the multiplier effect, service and retail sector jobs would also be lost. Indirect employment would be further impacted by reduced purchases of mine inputs.

4.11.2.3 Tax Revenue Generation

The Proposed Action would generate additional payroll, sales, ad valorem, and business and opportunities taxes as a result of increased direct and indirect employment and purchases of goods and services in the study area. This impact would be high and beneficial over the life of the project.

The proposed project would provide moderate to high beneficial impacts to needed government services through maintenance of the local tax base. Needed improvements to local schools and other community facilities would likely receive funding because the county would continue to have a sufficient tax base to support the issuance of bonds. Improvements to roads would also occur due to both direct construction and maintenance activities provided by Echo Bay or its contractors or through payments made by Echo Bay to the County for construction and maintenance. Two examples of funding that would be provided by Echo Bay to the County for road improvements include $90,000 for improvements that will be made to Old Kettle Falls Road, along with up to $5,000 per year for maintenance of that road and funding for design and improvements for the relocation of Wolfe Camp Road. The proposed project could also indirectly result in increased funding for improvements to Highway 21 by the State of Washington due to increased demands on the highway.

After the productive life of the Lamefoot Mine has ended, economic activity specifically associated with the Proposed Action would slow down. Direct and indirect employment and purchases of goods and services would diminish and consequently, tax revenue would decline.

4.11.2.4 Social Effects

Similarly, the social setting of Ferry County would be maintained during the proposed project by continued mining employment and its indirect population and business effects. Again, whether the social impacts of this continued employment are beneficial or adverse impacts depends on one's values. Traditional progress and growth arguments, as well as arguments for maintenance of current, rural lifestyles and a quiet setting suggest beneficial effects. For individuals who would prefer conversion of the local economy and society to a recreation and retirement orientation, the proposed project would probably generate medium adverse social effects. In any case, the mine could further perpetuate the social fabric of the County, balanced among the 3 or 4 employment sections noted above (Section 4.11.1.3). In addition, beneficial impacts associated with increased employment may also help to reduce the local crime rate, which appears to be correlated with the unemployment rate. A reduction in the local crime rate would constitute a moderate beneficial impact.

4.11.3 Alternative Backfill Methods

Socioeconomic impacts that would occur as a result of this alternative are the same as those described for the proposed action, since the method of backfill removal and transport to the mine would likely not influence socioeconomic factors, such as employment.

4.11.4 Alternative Haul Route

Socioeconomic impacts that would occur as a result of this alternative are the same as those described for the Proposed Action although expenditures by Echo Bay for improvements to Fish Hatchery Road would amount to $90,000 for construction and $50,000 annually for maintenance. These expenditures would be above and beyond those described for the proposed action and would constitute a low beneficial impact to the study area due to a slight increase in employment created by construction and maintenance activities.

4.11.5 Alternate Sub-County Road Backfill Access

The sub-county road backfill access alternative would have the same socioeconomic impacts as the proposed action.

4.11.6 Limited Mine Development - 2750' Level

This alternative would have direct and indirect beneficial impacts on employment and earnings in the Study Area, although for a shorter period of time than would be the case under the Proposed Action due to the limitation of the extent of mining.

4.11.6.1 Population

No significant influx of new workers and their families is predicted to occur as a result of the limited mining alternative, and no notable population-related impact would likely occur.

4.11.6.2 Employment and Earnings

This alternative would create approximately 33 new jobs at the Lamefoot mine, in addition to the 35 jobs that exist under the exploration program. The beneficial impacts that would arise from this employment and associated earnings would be the same as described for the Proposed Action (Section 4.11.2.2), although their duration would be for two years, rather than six. As a result, the reclamation phase would occur sooner, with employment dropping to 15 positions after the two year production phase. Continued operation of the key mill and the Kettle River Operations office would also be assured for two years as well.

Indirect economic activity stimulated by this alternative would also be similar to those described for the Proposed Action, although the shorter mine life would mean the indirect beneficial employment and earnings, impacts would also be correspondingly shorter in duration.

Since over time the productive life of the Lamefoot Mine would end. The beneficial economic impacts of direct and indirect employment and earnings would similarly end. Without the creation of new mining employment elsewhere, the number of mining jobs in Ferry County would decline. Based on the multiplier effect, service and retail sector jobs would also be lost. Indirect employment would be further impacted by reduced purchases of mine inputs.

This mining-related employment and earnings decline would occur within two to three years, since the amount of ore to be mined would be limited under this alternative.

4.11.6.3 Tax Revenue Generation

The beneficial tax revenue impacts associated with the Limited Mining Alternative would be the same as those described for the Proposed Action, although their duration would be two years rather than six. After the two year productive mine life, direct and indirect employment and purchases of goods and services would diminish and consequently, tax revenue would decline.

4.11.6.4 Social Effects

As described for the Proposed Action, continued mining would maintain the existing social fabric of Republic and Ferry County.

4.11.7 Limited Mine Development - 2741' Level

Socioeconomic impacts that would occur as a result of this alternative are the same as those described for the Limited Mining Development - 2750' Level (Section 4.11.6), since the physical access level of the mine (2741 feet versus 2750 feet) would not influence socioeconomic factors.

4.11.8 Mill and Tailings

Implementation of either the proposed action, alternative mining methods or alternative haul route project scenarios would boost production at the Key Mill to its capacity, and therefore promote employment of seven additional workers by Echo Bay. Current employment at the mill consists of 36 positions. Thus, 43 jobs would be either created or maintained by the project. These 43 jobs would generate approximately $1,849,500 in earnings annually for six years, and would constitute a high beneficial impact to the local economy. In addition, 30 contract jobs would be created during the 6-month construction seasons in 1994 and 1995, for expansion of the tailings pond. These 30 positions would generate roughly $645,000 in additional earnings during 1994 and 1995.

As described under the Proposed Action, mining-related employment indirectly stimulates employment in the retail and service sectors. The 43 positions and associated earnings at the Key Mill would likely generate or support 64 jobs and $737,000 in earnings in the retail and service sectors. The 30 half-year contract jobs associated with the tailings pond expansion would likely generate 22 jobs, with earnings of $254,000 in the retail and service sectors. Operation of the Key Mill over the life of the Proposed Action would result in purchases of inputs used in the Mill's operation. These purchases would also stimulate the local economy, since mostly local vendors would be used.

Over time, the productive life of the Lamefoot Mine would end. Since Lamefoot could be the primary or only source of ore to be processed at the Key Mill, the mill could potentially shut down when Lamefoot closes. Under this scenario, direct and indirect employment and earnings associated with the Mill would end after roughly six years. It is possible, however, that other mines (K-2) would open and contribute ore to be processed by the Mill. Under that scenario, Mill-related employment and earnings would continue.

Payroll, sales, ad valorem, and business and opportunities taxes would be generated by the Key Mill's operations, at least over the life of the Lamefoot project. These taxes would constitute a moderate beneficial impact to the local economy. After the Lamefoot project expired, the continued generation of tax revenue by the Mill would depend on operation of other mines and ore produced for processing.

4.12 CULTURAL RESOURCES

4.12.1 No Action

This alternative would not impact any additional cultural resources, sacred sites or Traditional Cultural Properties.

4.12.2 Proposed Action

The proposed action will not impact any known significant cultural resources. Significant cultural resources are defined as those eligible for or listed on the National Register of Historic Places. Native American consultation was addressed in Section 3.12.2; no additional consultation is required for the impacts of the proposed action.

4.12.3 Alternative Backfilling

This alternative would not increase the likelihood of impact to significant cultural resources, sacred sites, or Traditional Cultural Properties.

4.12.4 Alternative Haul Route

This route would be on existing roads and, with no construction or widening, there would be no impact to cultural resources, sacred sites, or Traditional Cultural Properties.

4.12.5 Alternate Sub-County Road Backfill Access

The sub-county road backfill access alternative would not impact any additional cultural resources, sacred sites, or Traditional Cultural Properties.

4.12.6 Limited Mine Development - 2750' Level

This alternative would have no impacts on cultural resources, sacred sites, or Traditional Cultural Properties.

4.12.7 Limited Mine Development - 2741' Level

This alternative would have no impacts on cultural resources, sacred sites, or Traditional Cultural Properties.

4.13 VEGETATION

4.13.1 Impact Methodology

Impacts on vegetation were identified and analyzed through a comparison of existing conditions with actual changes that occurred between the site visits in October of 1991 and 1993, relating that to the pre-June 1992 and post-June 1992 time frames, and superimposing additional changes anticipated from the proposed project.

4.13.2 No Action Alternative

Under the No Action Alternative, exploration and development would cease and the disturbed area would be reclaimed. Reclamation will include removing structures, regrading, ripping, topsoiling, seeding, and fertilizing. This activity will re-establish a vegetation community that is stable over the long term, and ecologically comparable to pre-mining conditions. Once revegetation is complete, there should be no long-term adverse impacts to vegetation, unless livestock are returned to the site. If livestock return, the condition of the vegetation in wetland areas will be degraded and the sensitive many-headed sedge will again be adversely affected to a low to moderate extent.

4.13.3 Proposed Action

The open stope mining utilizing backfilling is expected to have low adverse impacts on vegetation. Potential impacts include loss of a small amount of vegetated habitat during the life of the mine, and loss of habitat through soil erosion. A total of 9 or fewer acres of vegetation was eliminated by exploration after June 1992, and an additional 10 or fewer acres will be affected by the proposed action (see Soils, Section 4.8). This loss is considered low, because it will probably be offset by the continuing recovery of the formerly grazed area.

On the basis of the information presented in preceding sections (project description in Section 2.0; and hydrology in Sections 4.1 and 4.2), wetlands in the project area will not be adversely affected by the proposed action. None of the wetlands in the area will be filled or excavated by the proposed project. In fact, exclusion of livestock from the area will provide continued increased benefits to vegetative development in all wetland areas, many-headed sedge, present in the lower wetland area. Increased instability and soil erosion upstream of wetlands is also unlikely to occur, because of the plans for erosion control and runoff management presented in Section 2.0. Since the open pit alternative has been removed from consideration (and this was the only alternative that would impact wetlands on site), a formal wetland delineation is not considered to be necessary. Wetland boundaries in the dry climate of eastern Washington are obvious without a formal delineation, especially with the removal of grazing. These wetland areas were identified in previous studies (USFS 1992; Golder 1992c) and the proposed project was redesigned at that time to avoid impacts to wetlands.

The proposed haul road will use existing paved roads, which are in the process of being upgraded. It will therefore have the smallest direct (low adverse) impact to vegetation, as it will use the upgraded road surface under construction.

4.13.4 Alternative Backfill Method

The alternative backfill method will have low adverse impacts to vegetation, similar to those of the proposed action backfill method.

4.13.5 Alternative Haul Route

The alternative haul route would utilize existing roads, following Highway 21 and Fish Hatchery Road. This route would have low adverse effects, because increases in road width and sight distance would cause additional losses to vegetation over the proposed action haul route. Impacts are rated low adverse.

4.13.6 Alternate Sub-County Road Backfill Access

The sub-county road backfill access alternative will have low adverse impacts to vegetation, similar to those of the proposed action backfill method.

4.13.7 Limited Mine Development - 2750' Level

This alternative will have low adverse impacts to vegetation, similar to those of the Proposed Action.

4.13.8 Limited Mine Development - 2741' Level

This alternative will have low adverse impacts to vegetation, similar to those of the Proposed Action.

4.13.9 Mill and Tailings

The mill and tailings facility will expand to accommodate the Lamefoot ore, as previously permitted. Effects of the expanded tailings facility (Phase IIA) on native vegetation are not expected (see Section 4.8.5), or are expected to have no impacts. Phase IIB will impact 5 to 10 acres of native grasses and sparse ponderosa pine.

4.14 WILDLIFE

4.14.1 Impact Methodology

Impacts on wildlife were identified and analyzed through a comparison of existing habitat with the changes that occurred between the site visits in October of 1991 and 1993, relating that to the pre-June 1992 and post-June 1992 time frames, and superimposing additional changes anticipated as a part of the proposed project.

4.14.2 No Action

The No Action alternative will include reclamation, and will benefit wildlife in that the disturbed area will be reclaimed much more quickly than under the proposed action, and the acreage to be eventually disturbed and reclaimed will be smaller than that under the proposed action. Impacts are considered low beneficial, unless livestock grazing is returned at the previous intensity. That level of grazing will substantially degrade habitat quality in currently recovering areas, including the quality of deer winter range and potential spotted frog habitat.

4.14.3 Proposed Action

The proposed open stope mining using backfilling would have low adverse impacts on wildlife. This alternative would affect wildlife in several general ways: through habitat loss, increased human activity, and habitat alteration. Given the small size (approximately 10 acres) of the area to be disturbed, the impacts of habitat loss are expected to be correspondingly low adverse. The magnitude of the effects of habitat loss vary, however, depending on the type of habitat affected. None of the habitats that represent a small but important part of the study area, such as wetlands or aspen groves (which provide greatly increased habitat diversity for wildlife), will be affected. There will be a minor loss of mule deer winter range, but this loss is offset or even exceeded by the habitat quality improvement resulting from the removal of livestock. Deer are not currently avoiding this area, even though it is very close to the activities and buildings at the core shed and office complex. A doe and fawn mule deer were observed in the pond area just above the core shed during an October 1993 visit, and tracks, scat, and browse were abundant in the lower wetland area.

Increased traffic to the mine and between the mine and the mill could cause an increase in the risk of wildlife being struck by vehicles. Since this area is identified as deer winter range, the possibility of increased mortality from collisions could have a low adverse effect on local populations. Increased human presence in the area could reduce the use of the area by species sensitive to human disturbance, such as carnivores. All of these impacts are considered to be relatively minor (low adverse). No special status species are expected to be impacted by this project.

The proposed haul road will use existing roads and have an impact on wildlife similar to that of the alternative. The proposed route is the longest road alignment, and might therefore represent a higher collision hazard to deer and other wildlife from increased traffic; however, it would represent a lower level of disturbance to wintering deer than the alternative which is expected to cut through more deer winter range.

Under an informal consultation, the U.S. Fish & Wildlife Service has concurred with the BLM's determination that the Lamefoot Mine project is not likely to adversely affect the gray wolf, grizzly bear, and bald eagle, provided that the proposed operational and reclamation measures are carried out. Such measures include minimizing road construction, recontouring and revegetating disturbed roads, and reclaiming concurrently, where feasible (USFWS 1994).

Overall, the impacts of the proposed action are rated low adverse to wildlife.

4.14.4 Alternative Backfill Method

Under this alternative, use of the drop passes will eliminate some traffic and therefore provide a very low decrease in roadkill hazard to wildlife over the proposed alternative. The rating is not changed, and impacts are considered low adverse.

4.14.5 Alternative Haul Route

The alternative haul route would use an upgraded, existing road system and would therefore have a relatively small impact on wildlife in terms of both habitat loss and disturbance, although this road may also cross through additional mule deer winter range along Fish Hatchery Road.

Adverse effects from disturbance and collision hazard to wintering deer could also occur under this alternative. Overall, this alternative is also rated low adverse.

4.14.6 Alternate Sub-County Road Backfill Access

The sub-county road backfill access would have a low adverse impact to wildlife similar to those of the proposed action backfill method.

4.14.7 Limited Mine Development - 2750' Level

This alternative would have the same low adverse impacts to wildlife as those of the proposed action.

4.14.8 Limited Mine Development - 1741' Level

This alternative would have the same low adverse impacts to wildlife as those of the proposed action.

4.14.9 Mill and Tailings

Expansion of the mill and tailings facility will create additional loss of wildlife habitat in an area already subject to a high level of disturbance. Impacts are therefore considered low adverse.

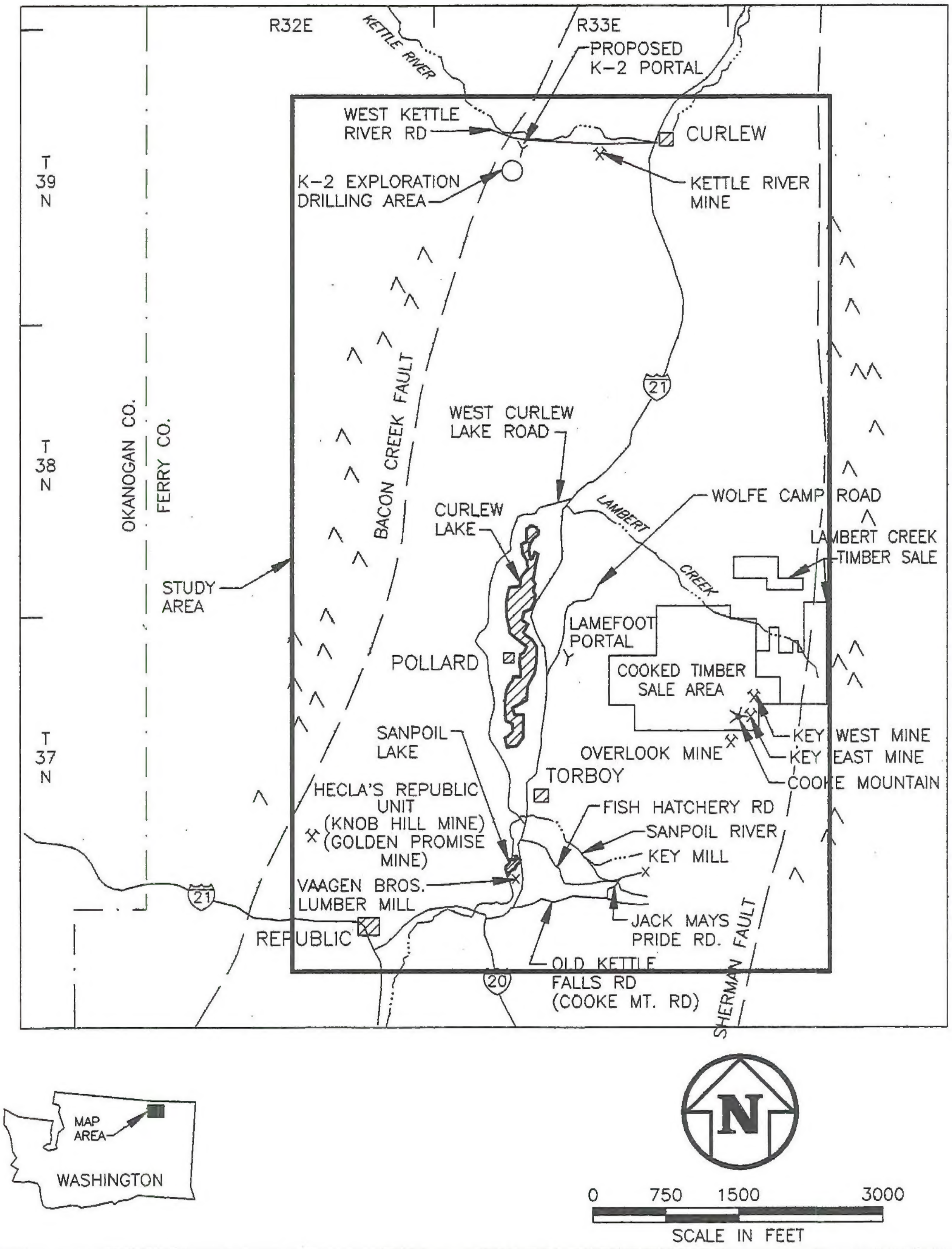
4.15 CUMULATIVE IMPACTS

This section presents potential cumulative impacts of the Lamefoot Project, by discipline, to the area outlined on Figure 4-15.1. First is presented a summary of local activities potentially contributing to impacts in the vicinity of the proposed Lamefoot Project. Following that summary are the resource discipline discussions.

KETTLE RIVER OPERATIONS MINES

Kettle Mine

- Opened for exploration October 1987 and closed in August 1988.
- Opened for commercial production in June 1989 and closed in September 1992.
- Underground mining for gold and silver, using long hole open-stoping as the primary mining method.
- 25 acres of disturbance - all on private land.
- Production rate averaged 300 tons per day, 5 to 7 days per week. The total amount of ore mined at the Kettle deposit was 246,000 tons.
- Waste rock removed and deposited in a permanent storage area totalled 120,000 tons. Recontouring and revegetation of storage area scheduled for 1993-1994.



ADAPTED FROM:
ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

Job No. : 23295
Prepared by : S.X.M.
Date : 10/26/93

GENERAL CUMULATIVE IMPACTS STUDY AREA WITH MAJOR REGIONAL LANDMARKS AND ACTIVITY CENTERS ADAPTED FROM ECHO BAY, 1993f

FIG. 4.15-1

- Ore haul varied from 200 to 600 tons per day, five days per week.

- Located west of the town of Curlew, and 21 miles northwest of the Key Mill

Overlook Mine

- Operation began in September 1988 and closed in December 1992.

- Underground mining for gold and silver using a combination of long hole open-stoping in a room and rib pillar configuration, and by room and post pillar methods. Backfill with cement was used to enhance ground stability.

- 53 acres of disturbance (including mine, associated facilities, and transportation route).

  - 45 acres of private land.
  - 3 acres of USFS land.
  - 5 acres of BLM land.

- Production rate averaged 1500 tons per day. The total amount of ore mined was 1.6 million tons.

- Ore was hauled on a private, unpaved road to the mill.

- Waste rock removed totaled 245,000 tons.

- As of July 1993, reclamation was 50% complete.

- The Overlook Mine is under a temporary closure status. Approximately 330,000 tons of gold bearing mineralization remains in the mine. This ore may be exploited in the future, based on economic factors.

- Located approximately 2 miles east of the Key Mill.

Key East and Key West Mines

- Operation began in October 1992 and closed in October 1993 because the surface minable resource was depleted.

- Two relatively small open pit areas for mining gold.

- 105.5 acres of disturbance (including mines, associated facilities, and transportation route).

  - 90.5 acres private land
  - 13 acres USFS land
  - 2 acres BLM land

- Production averaged 24,000 tons per day. The total amount of ore mined was 870,000 tons.

- Ore was hauled on an upgraded primitive road and a main access road.

- Waste rock removed totaled 4.8 million tons.

- Reclamation was started in 1993.
- Approximately 45,000 tons of ore grade material have been identified as an underground minable resource and may be mined by room and pillar mining method.
- Located 10 miles northeast of Republic.

Proposed Lamefoot Mine

- Exploration began in July 1992 and continues to the present.
- The proposed Plan of Operations is for an underground gold mine using a long hole open stoping mining method with backfill.
- An estimated 45 acres will be disturbed during exploration and production
    - 38 acres private land
    - 7 acres BLM land
- The production rate is estimated at 1,200 to 2,000 tons per day, 5 to 7 days per week. The total amount of ore is estimated to be 943,000 tons to 2,348,000 tons.
- Total waste rock is estimated to be 320,000 tons.
- Ore would be transported in highway haul trucks for processing at the Key Mill.
- Located 7 miles northeast of Republic.

K-2 Prospect

- Surface exploration began in 1990.
- Echo Bay submitted a Plan of Operations in October 1993 for activities associated with underground exploration, development, and mining of the K-2 gold deposit. If economic viability is established and the plan approved, full scale mining may occur as early as April 1995.
- Ore will likely be mined using the long hole open stoping method, and processed at the Key Mill.
- Based on current information, it is expected that production will be approximately 500-600 tons of ore per day.
- The haul route includes the West Kettle Road, State Highway 21, Old Kettle Falls Road, Jack Mays Pride road, and the Fish Hatchery road.
- Current plans call for approximately 18 acres of surface disturbance, all on private land.
- Located 3.5 miles west of the town of Curlew.

Key Mill and Tailings

- Constructed in 1989 to service the Kettle and Overlook mines, it now processes all gold ores produced by the Kettle River Operations.
- Ore is processed with the carbon-in-leach technique.
- Tailings are stored in a zero discharge, permanent tailings pond.
- A fully permitted expansion of this facility is set for 1993 to 1995.
- Currently, the Key Mill occupies 30 acres and the tailings facility occupies approximately 100 acres, all on private land. Following expansion, the mill and tailings facility will occupy a total of approximately 155 acres.
- Located 6 miles east of the town of Republic.

OTHER ACTIVE MINES IN THE VICINITY

Hecla's Republic Unit (aka the Knob Hill Mine)

- The Knob Hill claim was staked in 1897. Under several different ownerships, production was sporadic until 1936-7, when nearly continuous production began with open-pit mining.
- Underground gold mine.
- Production rate of approximately 450 tons per day, 5 days per week.
- Employs about 125 people.
- Located 2 miles northwest of the town of Republic.

LOCAL ECONOMY

Population

- The population in Ferry County, in 1990, was 6,295.
- 15 percent live in Republic, 85 percent live in unincorporated portions of the county.

Employment

Ranked from highest to lowest number of employees:

- Government
- Service industry
- Retail trade
- Manufacturing (primarily wood products)

- Farming/agriculture (including some timber related jobs) (ranked #1 in terms of total earnings, and #2 in most highly-paid jobs)

- Mining (ranked #3 in terms of total earnings, and #1 in most highly-paid jobs)

- Three largest private employers in 1992/1993

    - Echo Bay
    - Hecla's Republic Unit
    - Vaagen Brothers sawmill (located just south of Sanpoil Lake, employs over 100 people)

RECREATION

Curlew Lake State Park

- Located directly west across State Highway 21 from the Lamefoot Project.

- Recreation area with campgrounds, picnic areas, and boating facilities.

- The 1991 season had 97,000 visitor days, with peak use from June through September.

- Several private resorts operate on Curlew Lake, with a total of approximately 65 cabins.

Colville National Forest

- Located just over 1 mile east of the Lamefoot Project.

- Provides dispersed recreation activities such as hunting, fishing, camping, cross-country skiing, etc.

- Includes Kettle Crest Trail, a National Scenic Trail that runs from the Canadian border to the Colville Indian Reservation.

- State Highway 20, from the junction with State Highway 395 on east to the junction with State Highway 21 on the west, is a designated National Scenic Byway.

4.15.1 Groundwater

Assessment of the cumulative impacts to groundwater includes the effects of the overall Kettle River Project Operations. Cumulative groundwater impacts of mining are expected to be low adverse, since any disturbance attributable to a given action is likely to affect only the local hydrogeology. In the Lamefoot Project area, nitrate loading to groundwater would add to the existing nitrate problem in Curlew Lake, which is due to grazing, domestic septic systems, and natural nitrate loading (Juul and Funk 1988). Cumulative impacts from the proposed expansion of the Key Mill and Tailings Facility are also expected to be low adverse, assuming proper design, installation and operation of the tailings pond liner, underdrain, and monitoring system. Groundwater inflow and quality data from the Knob Hill Mine are sparse and not useful to this discussion.

4.15.2 Surface Water

The cumulative impacts study area for surface water quantity and quality includes a much broader study area than the Lamefoot project and, in general, involves all the mining operations in the Kettle River area. Cumulative impact areas would include the Key Mill operations, the Key East and West Mines, the Overlook Mine, the Kettle River Mine, the K-2 exploration, Hecla's Republic Unit, septic systems near Curlew Lake, a gravel operation south of Curlew Lake, and non-point source contributions from tributary watersheds of Curlew Lake. Minor degradation to water quality in both streams and lakes appears to be occurring due to the combined activities of logging, agricultural, recreational, mining, and commercial activity in the area watersheds.

It is not possible to determine the relative magnitude of all cumulative impacts to surface water based on the available data. However, if appropriate mitigation efforts are installed, operation of the Lamefoot Mine and associated expansion of the Key Mill Facility are expected to add only minor, if any, deterioration of water quality with respect to other operations in the Sanpoil watershed. Proper permitting and monitoring would ensure that the Lamefoot project does not add significantly to water quality and quantity deterioration.

4.15.3 Geochemistry

Cumulative geochemical impacts are partially addressed under the Surface Water and Groundwater portions above. Because many of the other regional mining operations (Figure 4.15-1 for the Kettle, Overlook, Key East and West Mines and Key Mill and Tailings) have each been operating for less than ten years, it may not be possible to evaluate cumulative long-term impacts to water quality. Also, a comprehensive review was not made of the water quality data for these sites and the Knob Hill Mine (Hecla's Republic Unit) was not within the scope of this FEISS.

4.15.4 Geology and Subsidence

No known subsidence issues have arisen for other Kettle River operation mines in the region. The nearest other operating mine in the area is Hecla's Republic Unit (aka the Knob Hill Mine) north of Republic, Washington. The mine has been extracting 10 to 30-foot thick (Devlin 1994) vein type gold deposits in competent, high-strength Tertiary volcanics. Traditionally, this mine has used unclassified tailings backfill, initially using the square set and fill method, and more recently using the horizontal cut and fill method. Historically, gold-bearing veins have been mined to the ground surface. In addition, disseminated low-grade gold ore has been extracted by glory hole pits at the surface. Current production is from the Golden Promise Vein at depths of approximately 1,800 feet (Devlin 1994).

The only similarities between geology and mining methods at the Hecla's Republic Unit and the proposed mining action at the Lamefoot deposit are:

1. Shallow depth of early mining at Hecla and proposed mining at Lamefoot
2. High-strength of the host rocks at both locations
3. Utilization of backfill at both locations

The only indication of subsidence at the Hecla's Republic Unit is the recent discovery of a single narrow fracture at the surface over a mined-out, near-surface and long abandoned narrow stope. This single surface fracture is evidence of trough subsidence and deflection of the crown pillar over the old stope.

The dissimilarities between the Hecla's Republic Unit and the proposed Lamefoot Mine are:

1. Host rock types: Tertiary volcanics at Hecla, and Permian limestone and Permian clastics at the proposed Lamefoot mine;

2. Ore veins: narrow (average 10 to 30-feet wide), isolated high-ore veins at Hecla, versus up to 140-foot wide potential veins and disseminated ore bodies at Lamefoot.

The lack of geologic similarity and gross differences in ore mineralization would make it impossible to use subsidence information measured at the Hecla Mine to quantitatively predict subsidence at Lamefoot. It is only possible to verify that the magnitude of subsidence effects will be extremely small, and produce very low adverse impacts.

4.15.5 Aesthetic Resources

The proposed action would represent a small incremental increase in the total amount of surface disturbance already existing at the Lamefoot site and at other mines in the area. The Key East and West mines are the only open pit mines associated with the Kettle River Project. Visual impacts of these open pit mines are considered long term because one of the quarries will not be reclaimed; however, these mines are located in areas that are not highly visible to most major viewing locations. Both open pit mines have depleted the surface minable resources and stopped operations in October, 1993. Other Kettle River Project mines are underground mines which, when reclaimed, will have low long-term impacts on the visual resources of the area. U.S. Forest Service timber sales on the Colville National Forest have also contributed to surface disturbance in the general area of the Kettle River Projects. The cumulative effect of these ground disturbing activities have not changed the overall natural appearance of the regional landscape.

4.15.6 Transportation

The cumulative effects study area for transportation includes roads used by traffic supporting any of the Kettle River Project facilities or other roads in the vicinity of the Lamefoot Project. The Lamefoot and the K-2 mines are the only Kettle River Project facilities that would be contributing traffic to State Highway 21 north of the junction with Old Kettle Falls Road. The K-2 plan of operations estimates that the K-2 mine, when operational (estimated to be 1996), would involve 17 round trip per day, or an increase of 34 ADT. Haul trucks from the K-2 mine would use the West Kettle Road, State Highway 21, the Old Kettle Falls Road, the Jack Mays Pride Road and Fish Hatchery Road. Combined haul traffic from the Lamefoot and K-2 mines would range from 94 to 174 ADT. This would result in a 6.6 to 12.3 percent increase in ADT from the estimated ADT for the section of State Highway 21 between the Wolfe Camp Road and the Old Kettle Falls Road. Total ADT for this section of the highway would range from 1,514 to 1,594, which is within the design capacity of the highway. Traffic impacts would be of the same type as described in the proposed action (section 3.6.2), but would increase in magnitude. The Key Mill also generates traffic, mostly employee and service vehicles. The Overlook, Key East, and Key West mines are currently inactive and are not contributing traffic to local roads. Any possible future activity at these facilities would not effect the haul route used by the proposed Lamefoot and K-2 operations.

An increase in logging trucks may occur on State Highway 21, Old Kettle Falls Road, and the eastern portion of Fish Hatchery Road as a result of future timber harvests in the area, but the exact amount of truck traffic associated with timber harvest activity is not known at this time. Recreation facilities such as Curlew Lake State Park and resorts surrounding Curlew Lake add to the overall traffic levels on both state and county roads within the study area. Construction on State Highway 21, planned for 1995, would add to traffic congestion and delays for users of the highway. The West Curlew Lake Road may experience some increase in local traffic as heavy truck traffic increases on State Highway 21.

It is not expected that the design capacity of any of these roads would be exceeded. Those sections of State Highway 21 between Old Kettle Falls Road and the Wolfe Camp Road that have not been upgraded to all-weather condition would experience an increase road surface deterioration. Cumulative effects to transportation would be considered medium to high adverse for State Highway 21 and medium adverse for the remaining roads comprising the haul route.

4.15.7 Noise

Current noise-producing activities in the region include drilling, surface support for underground exploration, and vehicular traffic. It is anticipated that the noise levels associated with other Kettle River Project activities are those typical of any mining venture. The major sources of noise during exploration include work associated with heavy equipment on construction and haul roads, drilling activities, and occasional blasting activities. Also, vehicular traffic to and from the site would contribute to the noise in the immediate, adjacent, and general areas. Noise levels at 50 feet from the sources are expected to be 90 dBA during daytime and 80 dBA at nighttime during construction activities, and 70 dBA during operations. Noise can be expected to decrease by 6 dBA with each doubling of distance and should not exceed the State of Washington maximum allowable environmental noise levels. Cumulative noise levels would be higher than if no industries were in the area. Vegetation would attenuate noise levels faster. Overall, regional noise impacts in a cumulative sense would continue to be low and adverse, considering addition of the Lamefoot project.

4.15.8 Soils

Past and proposed Echo Bay projects including Lamefoot project would result in the disturbance of land and soils totalling approximately 400 acres. Reclamation to meet productive post-mining land uses and federal requirements, where appropriate, will be conducted on both federal and private lands to reduce medium to high adverse short-term impacts to soils to low adverse long-term impacts.

4.15.9 Air Quality

Many activities which currently occur or are proposed in Ferry County produce the same kinds of emissions (vehicular exhaust and dust) as would be produced by the proposed project. Proposed activities which would result in such air quality impacts are discussed in Section 4.9.2 of this EISS. The air quality impacts of the proposed Lamefoot Project are very small relative to the emission rates from the various industrial sources as shown on Table 4.9-1. The Lamefoot project contributes less than 11.5 percent to the total uncontrolled fugitive dust emissions from the Kettle River Project, and less than 10.3 percent of all industry in the Republic area when considering emissions from the Hecla Knob Hill mine, and the Vaagen Brothers lumber mill. Gaseous pollutants from the Lamefoot proposed action contribute less than half of the total emissions of all projects considered. Yet, in comparison to other areas inside the northeast Washington air quality region, these cumulative impacts are rated low adverse.

Most important, the air quality of the region is generally good. TSP is the only pollutant monitored by the state in the Northern Washington Intrastate Air Quality Control Region, which includes the Lamefoot Project. Other pollutants do not exist in sufficient quantities to warrant monitoring. Implementation of the proposed Lamefoot Project as part of the Kettle River Project would not result in any appreciable change in this positive situation, and overall its cumulative effects to air resources are rated low adverse.

4.15.10 Recreation

The study area for cumulative impacts includes recreation areas in the vicinity of any of the Kettle River Project sites. Timber sales may affect dispersed recreation in portions of the Colville National Forest; however, recreational impacts associated with those projects are considered to be low. Other Kettle River Project facilities, such as the K-2 mine and the Key Mill, have little effect on recreation activities. Noise impacts at Curlew State Park may be considered medium adverse. Cumulative effects of any ongoing or future activities associated with the Kettle River operations, or with management activities in the Colville National Forest in the vicinity of any Kettle River Project facilities, on other recreation facilities or environments are rated low adverse.

4.15.11 Socioeconomics

The Proposed Action would have highly beneficial cumulative socioeconomic impacts on the study area due to the fact that Echo Bay's Kettle River operations as a whole would remain viable and operating for at least another six years. The following discussion describes the cumulative impacts of the Proposed Action on employment and earnings, indirect economic activity in the retail and service sectors, and tax revenue generation.

4.15.11.1 Employment and Earnings

An important cumulative socioeconomic impact of the Proposed Action and other Kettle River Operations would be the continued employment of approximately 30 Echo Bay workers at the headquarters of the Kettle River operations. The Lamefoot project itself would create 33 new jobs in addition to the 35 currently employed for exploration (Section 4.11.2.1). As described in Section 4.11.5, the Lamefoot project would also result in continued employment of roughly 36 current workers as well as create 7 new positions at the Key Mill. In total, the Proposed Action would result in full-time, year-round employment of roughly 141 people, not including an additional 30 contract workers during the summers of 1994 and 1995 for tailings pond expansion.

Since employment and earnings impacts for the Lamefoot Mine itself were described in Section 4.11.2, and impacts associated with the Key Mill and tailings pond were described in Section 4.11.5, the following discussion will focus on the impacts associated with the Kettle River operations office.

Continued employment of 30 workers at the Kettle River operations office would generate earnings of approximately $1,290,000 annually over the next six years. Purchases of equipment and supplies by the office and spending by Echo Bay employees in the local economy would indirectly create or support an additional approximately 45 jobs in the retail and service industries in Ferry County. This indirect employment would likely generate approximately $519,000 in earnings. These direct and indirect employment and earnings impacts would be highly beneficial to the Ferry County economy. When all direct and indirect jobs created and maintained by the Lamefoot project are added, the total cumulative employment impact of the Proposed Action is 355. Similarly, the total cumulative earnings impact of the Proposed Action is $8,496,500 per year. Table 4.15-1 provides a summary of total project-related impacts on employment and earnings.

With respect to the end of the productive life of the Proposed Action, it is unclear whether or not other Echo Bay mines would go into production to sustain operations at the Key Mill and Kettle River operations office. Assuming other ore bodies are discovered and extracted, future employment and earnings would be assumed. If no new mines go into production after the proposed Lamefoot Mine is reclaimed and closes, the Key Mill and Kettle River office would likely close, resulting in the direct loss of most or all of the 141 mining jobs created or maintained by the Proposed Action.

TABLE 4.15-1

CUMULATIVE SOCIOECONOMIC IMPACTS FOR THE LAMEFOOT PROJECT

Echo Bay Operation	Direct Employment	Direct Earnings	Indirect Employment	Indirect Earnings
Lamefoot Mine	68	$2,925,000	102	$1,176,000
Key Mill	43	$1,849,500	64	$737,000
Kettle River Operations Office	30	$1,290,000	45	$519,000
Total	141	$6,064,500	211	$2,432,000

Total Cumulative Employment: 355
Total Cumulative Earnings: $8,496,500

Similarly, the future of the indirect jobs and earnings generated by the Proposed Action is uncertain after the closure of the Lamefoot Mine. Production at new mines would clearly sustain indirect economic impacts, while a shut down at Echo Bay would probably result in a significant indirect economic slow down.

4.15.11.2 Tax Revenue Generation

Cumulative project tax revenue would be substantial over the life of the Proposed Action. Echo Bay would directly contribute payroll taxes for 141 employees, sales taxes for inputs purchased, and ad valorem taxes for its properties, and business and opportunities taxes as well. Expenditures by employees in the local economy would generate considerable sales tax revenue as well. Cumulative indirect employment and earnings generated by the Proposed Action would also generate considerable tax revenue for the state and local governments.

After the life of the Lamefoot project would expire, it is uncertain whether tax revenue generation would continue at the same level. If new mines open and employment and earnings were to continue at Proposed Action levels, tax revenues would probably remain similar. If mining activity declines or ceases entirely, tax revenues would certainly be reduced.

4.15.12 Cultural Resources

The study area includes the Key East and West mines, the Kettle River Mine, the Overlook Mine, the K-2 Prospect and the Key Mill. These locations are shown on Figure 4.15-1. Archaeological surveys for the four project areas identified 23 historic sites within the proposed (and actual) impact areas. None of these sites were found to be eligible for the National Register of Historic Places, however determinations of eligibility have not been sought for all recorded sites. No known prehistoric sites, Traditional Cultural Properties, or sacred sites located on the federal properties were affected by mining operations.

Table 4.15-2 shows the number of historic sites located by survey of the Echo Bay properties. The Key Mining Project includes the Key East and West Mines, and the Overlook Mine. Of the 23 sites recorded, seven have been impacted by mine-related activities. No sites determined eligible for the National Register of Historic Places have been impacted. The recorded sites consist mostly of mining-related remains and homesteads.

Key and Overlook Mining Projects

The majority of the sites were recorded as part of the Key Mine Project (Churchill 1988a). Approximately 1,700 acres of private and federally-managed land were surveyed. The area was revisited (Holstine 1991), and two sites originally recommended as eligible were reassessed. Holstine (1991) recommended that USFS Site 4309-04, collapsed cabins and adits, (also known as the Washington Lode Claim) and a segment of Old State Road No. 1, were not eligible. The Washington SHPO concurred with the updated recommendations (Griffith 1992). Eligibility determinations have not been sought for any of the other sites. Echo Bay mining activities impacted USFS Site 4309-04 and a segment of Old State Road No. 1. Other impacted sites (without eligibility determinations) include the Perkins Homestead, the Oversight and Copper Key mining complexes and the Cooke Mountain test pit. Churchill (1987), in his survey of 200 acres for the Overlook Mining Prospect, did not record any sites in the project area.

Key Mill and Tailings

Churchill (1988b) surveyed approximately 300 acres of private and federally-managed land. One site, the Zipfel Ranch, was recorded and impacted by the initial construction of the Key Mill and tailings. Churchill recommended the that the Zipfel Ranch was not eligible for the National Register of Historic Places. There

TABLE 4.15-2

HISTORIC SITES LOCATED BY MINE

Mine	# of Sites Recorded	# of Sites Impacted	# of Eligible Sites
Kettle River Mine (Granny Mine)	0	0	0
K-2 Prospect	1	0	0
Key Mill	1	1	*0
Key Mining Project (includes Key East, Key West and Overlook Mines)	21	6	**0

* Recommended not eligible, no SHPO consultation.

** Two sites were determined to be not eligible; there has been no consultation for the remaining sites.

is no documentation as to possible State Historic Preservation Officer (SHPO) concurrence, as there was no federal action at that time.

Kettle River Mine

Churchill (1988c) surveyed ten acres of this property and did not record any cultural resources. At the time survey was performed, the property was known as the Granny Mining Project.

K-2 Prospect

Holstine (1993) surveyed less than 100 acres. One 1950's era cabin was recorded and recommended as not eligible for the National Register.

Summary

Approximately 2,300 acres of private, BLM, and Forest Service lands have been surveyed for Echo Bay, in addition to the Lamefoot surveys. No prehistoric sites, Traditional Cultural Properties, or sacred sites were recorded. Twenty-three historic sites have been added to the archaeological record. The record of the four mine, prospect, and mill operations addressed here indicates that archaeological sites representing past use by Native Americans on all the properties, and Traditional Cultural Properties and sacred sites on federal properties, were avoided in terms of impacts. Seven historic sites were impacted by the Key Mill and Key Mine Operations.

4.15.13 Vegetation

Since the initial development of the Key Mill and associated projects, a total of approximately 330 acres of native grassland, shrubland, and forest have been disturbed. The Lamefoot project as proposed would add a temporary increment of approximately 45 to 50 acres of loss of vegetation until reclamation was completed. Much of this area will ultimately revegetate to the extent possible, and this impact is considered to be low adverse.

4.15.14 Wildlife

Overall, the Key Mill and tailings pond has resulted in habitat losses of approximately 155 acres. The Key East and West Pits affected 105.5 acres, of which a total of about 95 would be reclaimed after closure; one of the pits would remain, but would provide new cliff and talus habitat for a variety of wildlife species (Section 4.14 and Golder 1992d). The Overlook Mine eliminated 53 acres of vegetation. The Kettle Mine eliminated 25 acres. Except for the mine pits, most of this area will ultimately be reclaimed, although the productivity of former roads and the tailings pond will not be equivalent to the native, less-disturbed soils and forested habitats. The proposed Lamefoot project would add a temporary loss of 45 to 50 acres of habitat overall, and include adverse impacts to the eastern edge of an area of mule deer winter range. The probable impacts of the Cooked Timber Sale in the Colville National Forest are likely to have impacts of a far greater magnitude on wildlife in terms of fragmentation of habitat and loss of old growth habitat important to woodpeckers, lynx, wolves, grizzlies, wolverines, and wintering deer. Logging proposed in the Cooked Timber Sale certainly exceeds the area affected by Echo Bay mines by several orders of magnitude and affects currently unroaded areas. Road construction to provide access throughout the Cooked Timber Sale will also have substantial adverse effects on big game and large carnivores. Although these roads are often blocked after a sale, they are often still accessible to off-road and four-wheel drive vehicles and hunters (Palmenteer 1993). Increased pressure for recreational homesites and generally increasing population will also contribute to gradual "nibbling" and fragmentation of large habitat areas within the region (Zender 1993). Viewed within this context, the relative contribution of the Lamefoot proposal, even when combined with the Key East and West Pits, expansion of the mill and tailings pond, and potential development of the K-2 site, is low adverse compared to the other large-scale land use changes that are occurring.

4.16 RECOMMENDED MITIGATION

In addition to the commitments made by Echo Bay as part of the Proposed Action (Section 2.0), this impact analysis has suggested certain other mitigation measures, recommended for Echo Bay and permitting agency consideration. These measures follow by discipline.

4.16.1 Groundwater

The impacts discussion (Section 4.1) suggests certain mitigation measures that are recommended to address groundwater quality and quantity effects in the vicinity of the Lamefoot study area and the mill and tailings area.

- If acid drainage conditions develop, corrective action including additional grouting, diversion of surface flow away from mine infiltration areas, and treatment of mine discharge may be necessary.

- The potential groundwater inflow to the alternative backfill access may require mitigation by grouting or lining the tunnel, and/or diverting the flow to recharge the alluvium downstream from the tunnel to avoid depletion of the spring flow.

- Expansion of the tailings pond may affect the configuration of the local potentiometric surface. It is recommended that water levels be measured on a monthly basis in the three monitoring wells (TP-1,-2,-3) and in a sufficient number of the new wells or previous geotechnical borings which were completed as wells (ZB series holes) to evaluate the direction of groundwater flow. This information could then be used to assess whether the existing monitoring wells are downgradient of the tailings pond. Based on pre-Phase I water level data, a vertical gradient may exist in the tailings pond area. The possibility of downward movement of groundwater due to a vertical gradient may warrant the installation of deeper monitoring wells screened in the bedrock or lower water-bearing zone. Monitor existing wells monthly for field temperature, pH and SC and any other constituents required in permit. Also, consider adding total organic carbon (TOC), NH_3, major ions, and metals (EPA list) on a quarterly basis. It is recommended that this monitoring and any necessary corrective actions be coordinated through Washington DOE Permit 8033.

- Continued monitoring should be performed for domestic wells in the vicinity of project operations, and remedy or replacement of any water supplies adversely affected.

4.16.2 Surface Water

No surface streams are expected to be impacted directly by the proposed activities at the Lamefoot mine site and it is predicted the existing baseline conditions will be little changed. Project facilities are designed to store local surface water runoff, and could be considered as zero discharge facilities. The following mitigation measures are recommended:

- Erosion control measures could be provided for in areas of local disturbance. Sediment control structures would be designed to detain flows originating from disturbed surfaces, so that sedimentation will occur behind such structures.

- Natural sedimentation control occurs in existing wetland areas, and the further enhancement of such areas by maintaining near-natural flow patterns would be beneficial to the watershed in general.

4.16.3 Geochemistry

Many of the proposed mitigation measures identified in the Draft EISS (Sections 4.16.1 Groundwater, 4.16.2 Surface Water, and 4.16.3 Geochemistry) have been incorporated into the proposed action in the FEISS as design features. The mitigation measures identified below and shown on Figure 4.16-1 are in addition to the remaining measures identified in the DEISS that have not been incorporated into the proposed action.

Recommendations

1. The recommendation is that periodic reports (and any additional reports that may be needed) be used to determine mine impacts.

2. Monitoring Details

    a. Primary Level Measures - Internal Detection. Echo Bay has committed to an Internal Detection Monitoring of water volumes and quality within the plugged mine workings, as described in Section 2.3.5. The Hydrologic Monitoring Plan (Tables 2-5 through 2-7, and Figure 2-14a) provides additional details.

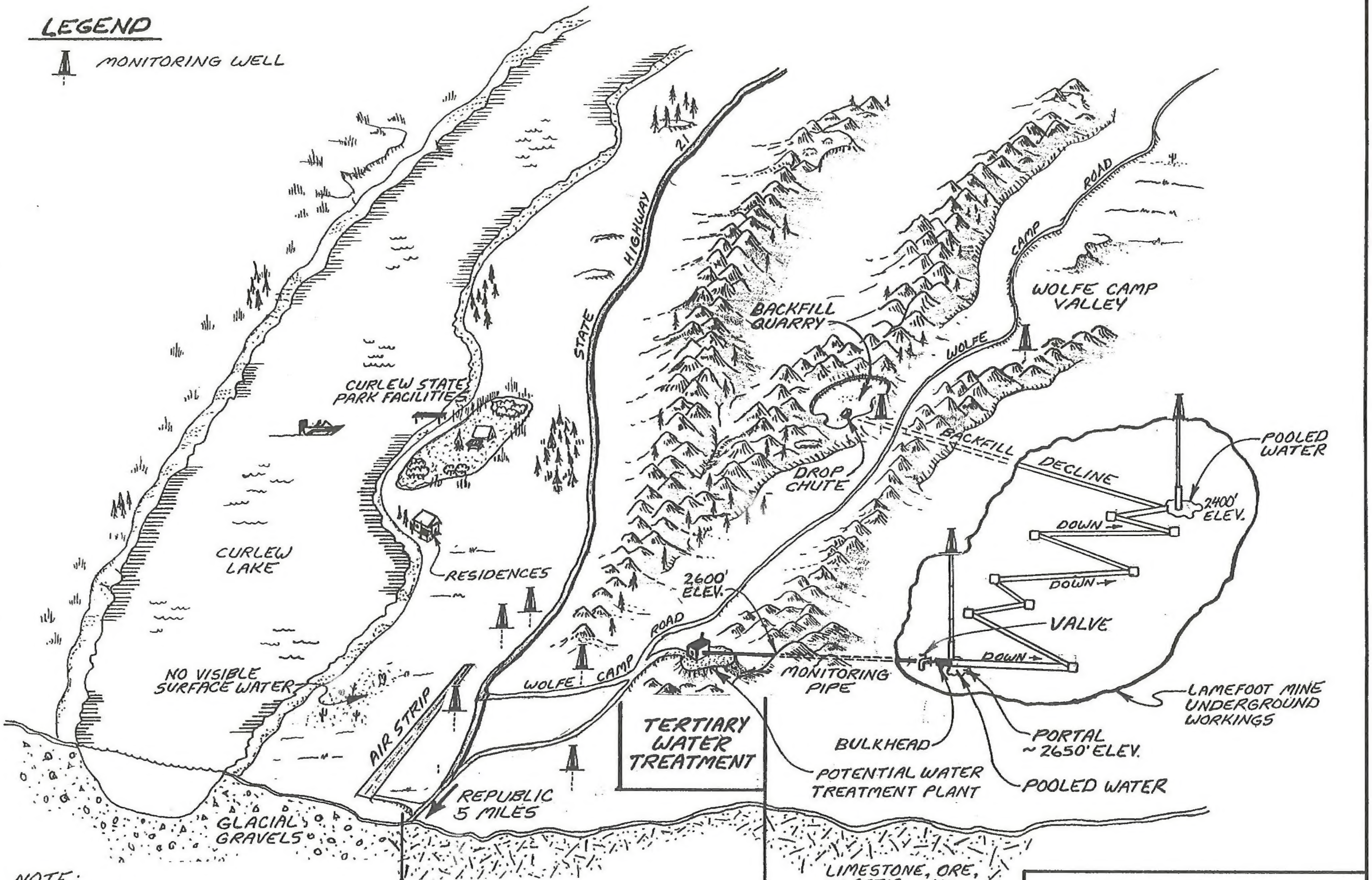
        - It is recommended that the 2 monitoring wells into the workings be constructed immediately upon mine closure.

    b. Secondary Level Measures - External Detection. Monitoring of the external wells and seeps are summarized in Section 2.3.5 of the FEISS, as noted above, and detailed in the Plan of Operations, Section 3.14.

        - It is recommended that a series of Trigger Levels be developed for several water quality parameters (e.g., pH, S.C., sulfate, iron, and zinc) by the regulatory agencies based upon natural background levels. When concentrations of these parameters in the Secondary Level (external detection) sites — wells, mine water, springs, and wetlands — exceed the Trigger Levels consistently for 90 days, the appropriate regulatory agencies should implement mitigation measures. Upon first noting an exceedance of the Trigger Levels, additional samples would be collected immediately following the reported exceedance, then monthly at the pertinent sites to verify the exceedance.

        - State of Washington Ground Water Quality Standards would serve as a basis for the development of these Trigger Levels.

    c. Tertiary Level Measures - Water Treatment Contingency - Echo Bay has commissioned the preparation of studies on several potentially appropriate water treatment technologies. The details of these studies are described in Section 2.3.5 of the FEISS and 3.13.5 of the May 1994 Revised Plan of Operations.



NOTE:
NOT TO SCALE, PRECISE LOCATIONS NOT SHOWN. NOT ALL MITIGATION MEASURES ARE SHOWN. SEE SECTION 2.3.5 OF THE FEISS FOR FULL DISCUSSION OF MITIGATION MEASURES AND EXACT WELL LOCATIONS.

SECONDARY LEVEL EXTERIOR DETECTION

PRIMARY LEVEL INTERIOR DETECTION

CONCEPTUAL DRAWING
POST-CLOSURE UNDERGROUND
WATER QUALITY
MITIGATION MEASURES
LAMEFOOT MINE PROJECT
REPUBLIC WASHINGTON

IG. 4 [illegible]-1

- It is recommended that, should Trigger Levels be exceeded at any of the Secondary Level sites, the appropriate regulatory agencies should consider the implementation of one or more of these treatment technologies. Specific treatment technologies would be evaluated based upon the actual chemistry of the water detected in the monitoring system at that time. Based on that evaluation, the agencies should direct the company to take appropriate corrective actions.

d. Agency Evaluation. It is recommended that the regulatory agencies periodically review the monitoring results and data interpretation during operations and post-closure. At those times, the agencies determine whether changes, if any, are needed to the program (see Section 2.3.5.5; Water Quality Monitoring discussions and the illustrating figure, Section 2.14b).

4.16.4 Geology and Subsidence

Level surveys are recommended in Appendix F, Addendum 1 of the Plan of Operations (Echo Bay 1993a) to monitor movement of the ground surface. The purpose of monitoring changes in the ground surface elevations over the upper stopes is to verify that collapse chimney development is not approaching the surface. It is anticipated that the measured surface deformations will verify the continuing stability of the ground surface during and after mining. However, the monitoring program will provide advance warning if the stability predicted is not achieved.

The proposed survey station spacing of 250 to 300 feet cannot provide sufficient detail of surface response above final mining areas, as shown on Figure 10 of the Plan of Operations. The largest stoping area, contiguous ore zones 3 and 4, is approximately 430 feet in the dip direction and 800 feet in the strike direction. The maximum dip direction width of 430 feet at approximately 60 degree dip (as shown on the figures in Addendum 2 of the Plan of Operations, Echo Bay 1993a) is foreshortened to either 215 feet in the horizontal direction, or to 248 feet of slope distance along the approximate 30 degree overlying surface slope to the east of Wolfe Camp Road. One station over the center of a stope every 250 feet along strike is not sufficient coverage to monitor for the development of trough subsidence. Additional, more closely spaced surface monitoring points are recommended, with a spacing on the order of 100 feet in the dip direction of the orebody and 200 feet in the strike direction of the orebody.

The surface monitoring stations (shown on Figure 1 of Addendum 1 to the Appendix F of the Plan of Operations, Echo Bay 1993a) are leveling stations. Leveling in this terrain would be time-consuming and labor-intensive (approximately two man days per down-dip line of monuments occupied and read plus one man-day for data reduction). It is recommended that these stations be redesigned for trivet plates and prisms and to utilize Electronic Distance Measuring (EDM) to increase monitoring speed and efficiency (these would require approximately two-man days to occupy and read plus one-man day to reduce the measurements). EDM monitoring would also measure the horizontal movement of the ground surface, which would permit both calculation of vertical and horizontal movement as well as the surface strains between monuments over the underground stoping operations.

The magnitude of predicted surface movements (less than 2 inches total) is so small that monitoring of the ground surface monuments over an individual active stope on quarterly intervals should be sufficient. Monitoring at shorter time intervals would probably produce measured displacements in the range of EDM accuracy. Annual monitoring of the ground surface over a fully extracted stope — for a period of five years after completion — should amply demonstrate that mining-induced deformation has slowed to less than the ability to measure accurately.

The purpose of the monitoring program is to verify that (a) 2 inches of deformation has not developed at the ground surface, or (b) that ground movements are not accelerating. Measured total downward displacement of the ground surface of 2 inches, and measured ground movement proceeding at a steady-state or accelerating rate, would indicate that the crown pillar is in the process of collapsing, and corrective measures should then be considered to stabilize the crown pillar (Figure 4.16-2 shows some crown pillar failure mechanisms). Corrective measures would involve either (1) providing backfill to fill more of the void at, or near, the top of collapse rubble in the near-surface stope, or (2) preparing to backfill the collapse chimney in the event the ground surface is breached. The indication that the crown pillar is in the process of collapsing would preclude re-entry to the stope for stabilization of the crown pillar and backfilling. Specifically, the MSHA would require Echo Bay to prepare and present a re-entry plan for approval. One alternative method of introducing additional backfill into the void is through drillholes angled into the void from the ground surface outside the stope. Another alternative method is to prepare for a breach of the overlying ground surface by stockpiling backfill material, in anticipation of a potential breach.

The post-mining mitigation recommended for the alternative backfill method is a water impoundment bulkhead within the access drift. The potential hydraulic head acting against this bulkhead will probably necessitate placing the bulkhead on the east side of the Wolfe Camp drainage to:

- Assure non-communication between the mine pool and the Wolfe Camp drainage, and
- Positively prevent hydrofracturing to the ground surface and release of water from the mine pool.

In addition, it may be necessary to install permanent support in the section of the alternative access tunnel that is directly below the Wolfe Camp drainage to eliminate any possibility of long-term subsidence (failure) to the overlying surface. The necessity for such permanent support can only be evaluated after the access tunnel is available for inspection.

4.16.5 Aesthetic Resources

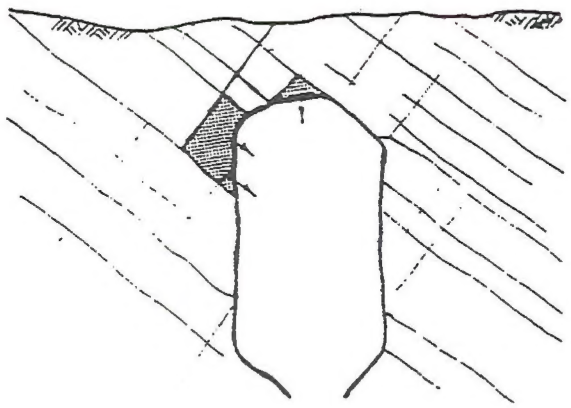
The following mitigation is recommended to reduce the overall level of contrasts created by exploration and mining and post-reclamation condition of the site and for the project to meet VRM Class III objectives. These mitigations are in addition to those already committed to in the conditions set forth in the approval of plan of operations (BLM 1992).

For reducing visual contrast, there are three generic types of mitigation techniques: (1) strategic location; (2) minimization of disturbance; and (3) facility design with consideration given to repeating or borrowing from the basic landscape elements of line, form color and texture. The following mitigation recommendations will help reduce visual contrasts created by both the exploration and mining project facilities.

- Color contrasts created by the waste rock stockpiles, the exposed soil and rocks surrounding the portal area, and the upper exploration drill road may be reduced through either staining or covering with a soil medium and seeding. The most effective method for reducing contrasts created by the upper drill road may be to hydro-mulch the sidecast and to stain exposed rock surfaces. Rock staining may produce the best results for reducing contrasts created by the waste rock stockpiles. Hydro-mulching and rock staining may provide the best method for reducing contrasts on the exposed surfaces surrounding the portal area. Mitigation of waste rock stockpiles would apply to those rock faces remaining after initial waste rock removal for backfilling has occurred.

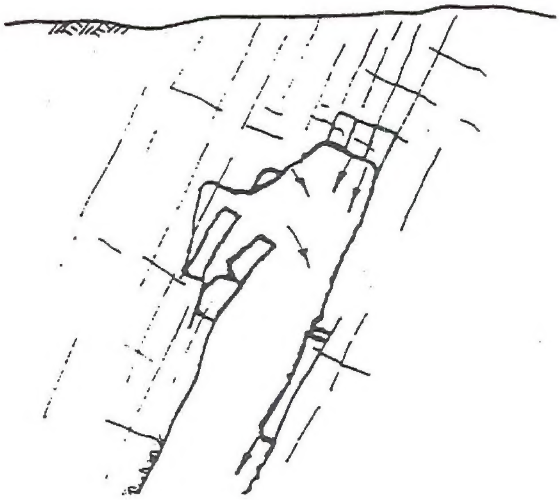
EXAMPLES OF POTENTIAL CROWN PILLAR FAILURE MECHANISMS

Figure 4.16-2



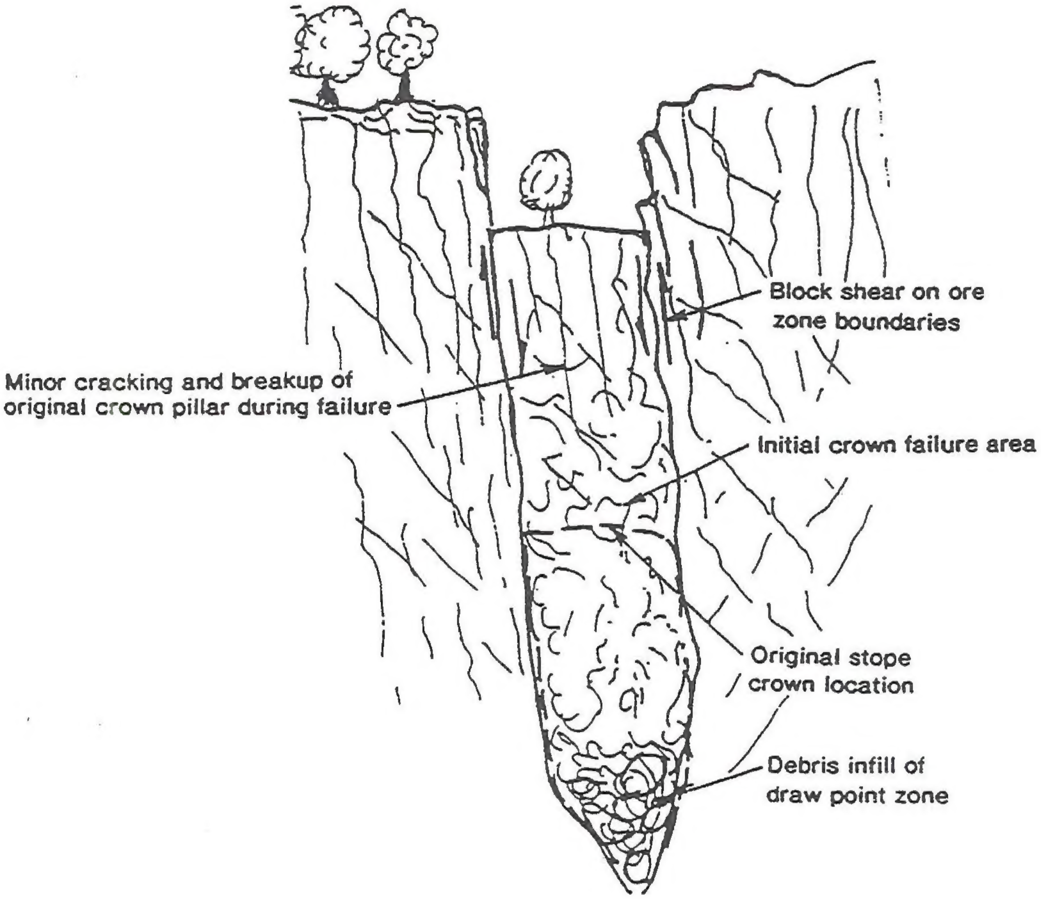
PILLAR RAVELLING

Potential stability problems in blocky ground due to wedge failure.



PILLAR UNDERCUTTING

Potential stability problems in slabby ground due to wall failure and undercutting of back.


Block shear on ore zone boundaries
Minor cracking and breakup of original crown pillar during failure
Initial crown failure area
Original stope crown location
Debris infill of draw point zone

CHIMNEY FAILURE

Potential stability problems due to continuous planes of weakness in stope hangingwall/footwall

SOURCE: ECHO BAY, 1993a

- Vegetative screening should be planted in strategic locations south of the mine entrance road to provide screening of project facilities. Species selected should be fast growing trees that are at least 8-10 feet tall at time of planting.

- Surface disturbance caused by excavation activities on the west side of the Wolfe Camp Road should stay within the "not seen" area as shown on the topographic visibility map (Figure 3.5-1).

- A terraced excavation facility plan for the excavation site along Wolfe Camp Road may provide a facility that will blend more effectively with the surrounding landscape by providing benches where vegetation may become established once excavation is complete.

- Clearing of land for project facilities (excavation site and mill expansion) should create curvilinear lines instead of straight lines, and vegetation adjacent to the site should remain as undisturbed as possible for maximum screening of the facility. Dumping of excess material during excavation on down or side slopes should be avoided.

- Echo Bay should continue their practice of instructing employees and sub-contractors on the importance of obeying all traffic regulations and, for haul truck operators, practicing quiet driving techniques, such as reducing engine rpm's before downshifting. These techniques will help reduce noise and aesthetic impacts to residents along the route and recreationists at Curlew State Park.

4.16.6 Transportation

- Echo Bay should continue the practice of instructing employees and sub-contractors on the importance of obeying all traffic regulations and, for ore haul trucks, to require drivers to practice quiet driving techniques, such as reducing rpm's before downshifting. All project related vehicles, including sub-contractor owned haul trucks, should be adequately maintained, primarily with respect to mufflers.

- Echo Bay should encourage car-pooling among its employees.

4.16.7 Noise

Committed noise mitigation measures for the proposed action were discussed in Section 2.0 of this document. Additionally, Echo Bay would conform with all MSHA noise regulations. These require that workers not be exposed to over 90 dBA noise levels for 8 hours, 100 dBA noise levels for 2 hours, and 115 dBA noise levels for 15 minutes.

Properly maintained equipment, with noise attenuating apparatus and advanced muffler technology, would be used to reduce noise levels associated with on-site construction activities. Contractors would be instructed to schedule the noisiest operations for daylight hours.

Primary crushing of ore should be accomplished in enclosed structures. Transportation of ore from the Kettle River Mine Site to the Mill would be scheduled for the dayshift. Given that only 30 to 70 roundtrips per day would be required for hauling ore to the mill site from the Kettle River Mine, the overall noise generated by ore transportation should be minimal if proper and courteous shifting/accelerating/driving techniques are followed.

Noise level monitoring may be required if nearby residents issue complaints. Monitoring would substantiate claims of exceedance of State noise level limits, and allow Echo Bay to devise and initiate corrective action.

4.16.8 Soils and Reclamation Potential

Most of the mitigation measures for impacts to soils are presented in the Reclamation Plan for the Lamefoot project area (Appendix E). Suggested additional measures or modifications of measures are listed below:

- Other sources of suitable coversoil material should be identified and characterized, if use of other sources is planned.
- Use of completely native seed mixtures for reseeding of private lands during interim and final reclamation should be considered.
- Expand the noxious weed control program to include inventory of the type of weeds, treatment methods, appropriate herbicides for specific species application rates, timing, and other appropriate items to ensure adequate control and protection of desirable plant communities.
- Releases or spills of petroleum-based products on wastes which contaminate soil materials should be cleaned up (excavation of contaminated soil), and properly disposed of according to procedures developed by the Washington Department of Ecology.
- Upon removal of the waste rock piles as part of mine stope backfilling, underlying soils should be sampled and tested for acidification and metals contamination. Should the results indicate contamination has occurred, an appropriate response to ameliorate or remove the contaminants would be designed and implemented.

4.16.9 Air Quality and Meteorology

- Use of fugitive dust controls - water sprays on haul road, wetting of ore, misting of borehole exhaust, baffling for ventilation system
- Use of BACT on emissions sources at mine and mill/tailings compound

4.16.10 Recreation

Mitigation for recreation resources are related to reduction of visual and noise impacts. (See mitigation recommendations for visual resources and noise found in this section.) No other mitigations are recommended.

4.16.11 Socioeconomics

No additional mitigation measures are recommended for socioeconomic impacts.

4.16.12 Cultural Resources

If previously unknown cultural resources are encountered during mining or construction activities, all development activity should cease in the vicinity of the resource. The resource will be examined by a qualified archaeologist who will prepare a report for the BLM. Development activity will not recommence until the BLM approves the action. These mitigation measures are required by existing laws and regulations.

4.16.13 Vegetation

The low adverse impacts on vegetation of this proposed mine can be minimized by a number of actions. These include the following, given below as recommended mitigation measures for the proposed project.

1. Minimize the area disturbed by equipment.

2. Monitor stormwater treatment and drainage systems to insure that wetland areas are protected from silt-laden runoff from disturbed areas. Continue monitoring the spring that feeds the lower wetlands and provide an alternate water supply to the wetland if the spring dries up.

4.16.14 Wildlife

Adverse impacts on wildlife can be minimized by the following mitigation measures:

1. Site the waste rock/backfill storage areas away from the important habitats listed above. If possible, configure the waste rock/backfill storage areas to provide habitat similar to talus and/or rock outcrop, to enhance wildlife habitat diversity. If this is not possible, any reclamation of such areas should be designed to provide habitat diversity, such as a meadow area within the surrounding forest.

2. Educate mine workers on how to avoid vehicle collisions with wildlife.

3. Continue livestock exclusion from formerly grazed areas as this has already provided substantial habitat gains to offset habitat lost to mine exploration.

4. Reclaim all possible exploration access roads to ensure they are as impassable to all types of motorized vehicles as undisturbed areas.

5.0
OTHER EISS PROCEDURAL ISSUES

5.0
OTHER EISS PROCEDURAL ISSUES

This section addresses various other impact issues required in the EISS, according to the National Environmental Policy Act (§§ 102 (2) (c) (ii), (iv), and (v)); and Council on Environmental Quality regulations (40 CFR 1502.16).

5.1 UNAVOIDABLE ADVERSE IMPACTS

The following are adverse environmental effects which cannot be avoided should the proposed action be implemented.

5.1.1 Groundwater

The proposed project will produce localized adverse effects on water quality in both the mine and tailings areas.

5.1.2 Surface Water

The proposed project will not adversely affect surface water.

5.1.3 Geochemistry

The proposed project will expose fresh geologic materials, which will increase water-rock reactions (i.e., Wolfe Camp quarry, mine workings, waste rock piles). Some degradation of groundwater quality will occur within backfilled mine workings.

5.1.4 Geology and Subsidence

A minor deflection of the ground surface, less than one and one-half inch, will occur over the maximum 65-foot wide near-surface stopes as the result of the proposed backfill mining. Minor rock movements toward mined openings will locally increase rock mass permeability.

5.1.5 Aesthetic and Visual Resources

There will be an increased area of surface ground disturbance at the excavation site west of Wolfe Camp Road, and noise and visual impacts to residences along haul route.

5.1.6 Transportation

Heavy truck traffic will increase on State Highway 21, Old Kettle Falls Road, Jack Mays Pride Road and Fish Hatchery Road.

5.1.7 Noise Levels

Increased noise levels will be an unavoidable adverse impact. The noise levels will return to previous levels after completion of the project.

5.1.8 Soils

The proposed project will produce:

- Loss of pedogenic development in areas of surface facilities construction and operation
- Loss of soil material due to erosion
- Loss of soil/vegetative productivity in areas occupied by facilities for life of operations

5.1.9 Air Quality and Meteorology

The proposed project will not adversely affect the local climatology nor meteorology.

The proposed project will increase ambient concentrations of particulate matter during the life of the project. Particulate matter levels should return to pre-project levels after completion of the project.

5.1.10 Recreation

Noise impacts will increase to Curlew Lake State Park and adjacent recreation homes and users.

5.1.11 Socioeconomics

Social setting and quality of life of Ferry County will change. This could be adverse and temporary depending on one's values. There will be minor changes to congestion, crime, and traffic accident rates in the county due to increased population.

5.1.12 Cultural Resources

There will be no adverse impacts to significant cultural resources.

5.1.13 Vegetation

If livestock grazing use is re-established after mine closure, the lower wetland area and sensitive sedge species will be adversely affected.

5.1.14 Wildlife

The proposed action could cause increased risk of road kill mortality to mule deer from mine-related activities on winter range.

5.2 SHORT-TERM USES VS. LONG-TERM PRODUCTIVITY

Following are relevant issues by discipline concerning the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

5.2.1 Groundwater

During production, the mine openings and their associated effects will intersect some surface and groundwater and divert it to the access tunnel portal, temporarily bypassing the intermittent creek along Wolfe Camp Road. After mining, the proposed bulkheads in the access and backfill tunnels should reestablish the approximate pre-exploration surface and groundwater conditions.

5.2.2 Surface Water

The surface water issue is not applicable.

5.2.3 Geochemistry

Groundwater within the mine workings that becomes chemically degraded could not be used for other human activities without being treated.

5.2.4 Geology and Subsidence

Mining involves the removal of a nonrenewable resource. There will be negligible long-term subsidence.

5.2.5 Aesthetic and Visual Resources

Excavation along Wolfe Camp Road will degrade the scenic quality of Wolfe Camp drainage for the long-term.

5.2.6 Transportation

There will be long term improvements to county and state roads.

5.2.7 Noise Levels

Noise levels in the vicinity of the Lamefoot project will increase in the short-term, during the life of the project. However, in the long-term, noise levels will revert to the original levels from before the project. Noise levels around the mill will remain elevated for as long as ore in the area needs to be processed.

5.2.8 Soils

Effective reclamation of disturbed areas would restore lost soil productivity for the long-term.

5.2.9 Air Quality and Meteorology

Ambient air quality concentration levels will increase during the short-term, or life of the Lamefoot project. However, air quality should return to pre-exploration levels at the Lamefoot site when the project is complete, and to pre-mining levels when ore is exhausted.

5.2.10 Recreation

Short term impacts to recreation will be eliminated after reclamation.

5.2.11 Socioeconomics

Use of minerals in the short-term would forego their future use in maintaining the county economic base.

5.2.12 Cultural Resources

There are no trade-offs for cultural resources in the short- or long-term.

5.2.13 Vegetation

Over the long-term, the vegetation of the Lamefoot area will remain essentially the same in terms of productivity. Over the short-term, removal of grazing has enhanced local vegetation to the point that the enhancement probably offsets losses to mining.

5.2.14 Wildlife

Over the long-term, wildlife habitat quality and quantity will remain essentially the same. Short-term enhancement of forage through removal of grazing provides benefits to wildlife during the life of the mine.

5.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Following are any irreversible and irretrievable commitments of resources which would be involved should the proposed action be implemented. Such commitments by discipline are:

5.3.1 Groundwater

The groundwater quality in backfilled mine workings would not be suitable for domestic consumption.

5.3.2 Surface Water

The surface water issue is not applicable.

5.3.3 Geochemistry

Geochemical reactions will continue after rock units are exposed through the mining process.

5.3.4 Geology and Subsidence

The higher-grade portion of the orebody would be extracted, and would not be available for future exploitation.

5.3.5 Aesthetic and Visual Resources

Topography and visual quality at the excavation site in the Wolfe Camp drainage would represent a irretrievable change from existing condition.

5.3.6 Transportation

The transportation commitment is not applicable.

5.3.7 Noise Levels

There would be no irreversible commitment of ambient noise resources, because noise levels would return to the previously existing noise levels.

5.3.8 Soils

There would be irreversible/irretrievable commitments of resources loss of soil material due to erosion and loss of soil/vegetative productivity for life of facilities.

5.3.9 Air Quality and Meteorology

There would be no irreversible and irretrievable commitment of local climatology, meteorology, or air quality, although air quality resources would be impacted during the life of the project.

5.3.10 Recreation

The recreation commitment is not applicable.

5.3.11 Socioeconomics

There are no socioeconomic commitments noted.

5.3.12 Cultural Resources

There will be no commitment of significant cultural resources.

5.3.13 Vegetation

Topography will be changed over the long-term, but these changes are not expected to affect any sensitive vegetation features.

5.3.14 Wildlife

Similar to vegetation, topographic changes are not expected to affect any sensitive wildlife features.

6.0
CONSULTATION AND COORDINATION

6.0
CONSULTATION AND COORDINATION

This EISS was prepared by an interdisciplinary team of specialists from the Bureau of Land Management, Spokane District Office and Woodward-Clyde. As an integral part of the preparation process, consultation and coordination were carried out with the following federal, state, and local governmental agencies, Native American tribal representatives, and members of special interest groups and the general public.

6.1 PUBLIC PARTICIPATION

Comments, suggestions, and concerns about the proposed project were gathered during a public scoping period from May 7, 1993 through June 7, 1993. A public scoping meeting was held in Republic, Washington on May 20, 1993.

6.2 PUBLIC COMMENTORS

Public Meeting Attendees:

Robert C. and Margaret A. Hirst, HC 71 Box 78A, Oroville, WA 98844
Susanne and Ron Gerde, 852-16 Pete's Retreat Rd., Republic, WA 99166
Greg Pezoldt, 4122 Crestview Lot 32, Kettle Falls, WA 99141
Joyce Weaver, P.O. Box 105, Republic, WA 99166
Mike Petersen, P.O. Box 223, Republic, WA 99166
Walt Hunt, Echo Bay representative
Hank Lisinski, Echo Bay representative
Jessy Graser, 694 Trout Creek Road
George Brown, BLM, Spokane, WA
Zella M. and Lawrence McFarland, Star Route Box 83E, Oroville, WA 98844
Patrice Beckwith, Soil Conservation Service, P.O. Box 315, Republic, WA
Larry Beardslee, 408-3 Old Kettle Falls Rd., Republic, WA 99166
Reed and Deborah Heckly, P.O. Box 687, Republic, WA 99166
Tom Hern, P.O. Box 829, Republic, WA 99166
Ed Windsor, 3444 Torodo Cr. Rd., Wauconda, WA 98859
Daina L. Bambe, 975-2 Rose Valley Road, Republic, WA 99166
Richard D. Dehslinger, 975-2 Rose Valley Road, Republic, WA 99166
Fred O. Heckly, 1023 Dollar Bar Rd., Republic, WA 99166
Ron Clayton, 2617-1 E. Kettle River Rd., Curlew, WA
John Ennis, P.O. Box 551, Republic, WA 99166
Dan Anderson, 190 Knob Hill Rd., Republic, WA 99166
Sandy Barbero-Younghi, 655 Fish Hatchery Rd., Republic, WA 99166
Jerry D. Knapton, P.O. Box 305, Republic, WA 99166
Harold and Paula Litz, 591 Fish Hatchery Rd., Republic, WA 99166
Mari Bremmer, Republic, WA 99166
Todd Christensen, Star Rt. 85, Oroville, WA 98844
Myron Sawiuk, Star Rt. 85, Oroville, WA 98844

Written Comments:

1. Susanne and Ron Gerde, Republic WA, 7/7/92
2. Reed Heckly, (Republic, WA), 6/29/92
3. David A. Hoppens, Malo WA, 6/27/1992

4. Adeline Fredin, Nespelem, WA, 6/25/92
5. Larry Beardslee, Republic WA, 6/23/93
6. Chris A. Carrel, Seattle, WA, 6/10/92
7. Patrice Beckwith, Spokane, WA, 6/7/92
8. Todd Christensen, Colton, WA, 6/6/93
9. Myron Sawiuk, Oroville, WA, 5/28/93
10. Mike Petersen, Republic WA, 5/28/93
11. Joyce Weaver, Republic, WA, 5/20/93
12. Jerry Graser, Republic, WA, 5/20/93
13. Tom Hern, Republic, WA, 5/20/93
14. Daina L. Bambe & Richard Dehslinger, Republic, WA, 5/20/93
15. Reed Heckly, Republic, WA, 4/20/93

6.3 AGENCIES AND ORGANIZATIONS CONSULTED

6.3.1 Federal Agencies

U.S. Department of the Interior, Bureau of Land Management
U.S. Department of Agriculture, Forest Service, Colville National Forest
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Soil Conservation Service
U.S. Environmental Protection Agency
Bureau of Reclamation

6.3.2 State Agencies

Washington Department of Ecology
Washington Division of Wildlife
Washington State Parks and Recreation Commission
Washington State Department of Transportation
Washington Department of Social and Health Services

6.3.3 Local Agencies

Ferry County Commissioners
Ferry County Highway Department
Ferry County Department of Public Works
Republic City Planner

6.4 COMMENT ANALYSIS

The following comments are summarized by issue, primarily as received from the public (Section 6.2). In some cases, the comment is quoted; in others, it is paraphrased in the form of a statement, phrase, or question to attempt to capture its essence.

SOCIOECONOMICS

- Economic (employment) support from the mine has been inconsistent.
- Negative impact on tourism industry (thus local economy) due to decreased water quality.
- The economic stimulus (of the mine) has saved the area from recession.

- The mine is essential to the economy of Republic and Ferry County.
- Long-term employment will benefit from the proposed project.
- This project is good for the economy of the area.
- Tourists can be taken to the site to generate revenue.
- What are the costs to the BLM from the Lamefoot project?
- What direct revenues will BLM receive from Echo Bay?
- Public concerns merit a thorough study of the socioeconomic impacts.
- What are the economic effects of this project on the non-mining community, including the loss of property value, degradation of the quality of life for local residents and increased burden on county infrastructure?
- County Assessor and Auditor reports and the federal tax returns on Echo Bay should be studied during the economic analysis (to determine the financial stability of the company).
- Economic values should be assigned to visual, noise, transportation and ore hauling in order to factor impacts on them into the socioeconomic analysis.
- Most jobs at Echo Bay are short-term/unstable and increase loads for the community service programs.
- What are the economic impacts of groundwater contamination?

CULTURAL RESOURCES

- A full and comprehensive Cultural Resources Survey should be conducted.
- The project has the potential to disturb or destroy archaeological and cultural resources of the Colville Confederated Tribes.
- Historically, this area was part of the hunting grounds for Native Americans.

VISUAL

- Scarred landscape.
- The exploration road above Wolfe Camp Road creates a visual disturbance (particularly from west Curlew Lake Road). Can this impact be mitigated?
- Negative visual impact on Curlew Lake residents and recreators.
- Night lighting should be minimized (but still address safety concerns).
- Economic value should be put on visual impact.
- Measures should be taken to reduce visual impacts, reduce unnatural lines, blend stockpiles and bankcuts back into the landscape.

WILDLIFE

- Mule deer habitat, including their water source, needs to be protected.

LAND USE/RECREATIONAL

- Why is a major industrial operation being located less than half a mile from the major recreational site in Ferry County?

AIR/NOISE

- Underground ventilation fans pose potential noise disturbance; mitigation measures should be encouraged.
- Air quality standards violated due to levels of cyanide in the tailing ponds.
- Drilling should not be conducted late in the evening or night due to close proximity of private residences.

- Steady noise is not bad, but fluctuating noise levels are irritating.
- Noise pollution must be addressed in terms of the cumulative impact of the mine (blasting, machinery, trucks, etc.) and existing noise such as recreational activities, highway traffic.
- Ore trucks traveling in low gear between the portal and stockpiles should be quieted (muffled).
- Residents should be compensated for noise-related disruptions and inconveniences.
- Mitigation is needed for noise disturbance from underground haul trucks and excavation of backfill material.
- Mitigation is needed for dust caused by increased operations traffic.
- Noise from excavation of backfill material will disturb residents (suggest daytime blasting only with notification to neighbors).

GEOLOGY/GEOCHEMISTRY

- What are the environmental impacts of adding material from the Lamefoot project to an expanded tailings impoundment?
- Consider new technologies for cyanide destruction and control.
- What assurances are there that the project will not add to the ore processing and acid drainage problems.

HYDROGEOLOGY

- Key Mines processing mill and exploratory drilling may be impacting the watershed (Curlew Lake area).
- Water quality (of Curlew Lake) may be negatively impacted by the mine.
- Effect of non-point source pollution from the mine on local water quality.
- Drill holes should be sealed promptly to minimize groundwater contamination.
- Private well exists within 200-300 feet of proposed drill pads.
- Excessive amounts of fugitive dust or surface runoff should not be allowed to end up in Curlew Lake.
- Who will pay for the mitigation of contaminated groundwater?
- What measures can ensure that groundwater will not be impacted by the operations?
- Will the mine impact local/private water supplies, especially Heckly's well, within 2,000 feet of mining operations?
- How is and how can the groundwater be monitored downgradient in the direction of Curlew Lake?
- What is the worst case scenario for dissolved solids and acid-producing rock to present the potential range of contamination?
- Dissolved solids may intrude into the groundwater.
- Potential threats to the community well (at the bottom of a draw that leads west across the highway, from the Lamefoot site) should be investigated.

POLICY/OPERATIONS

- Reclamation bond is not adequate to cover the cost of complete mitigation.
- Lead agency is not local, so local agencies feel powerless.
- Has the Ferry County mining ordinance been followed?
- All typical types of pollution should be addressed (and the corresponding regulations).
- Cumulative effects of Lamefoot in conjunction with past, present, and future mining in the area should be taken into consideration.
- Is the old mine facility and tailings impoundment suitable for the new mining project?
- Is the bond adequate to address worst case scenarios?
- Address mitigation and restoration in the event of groundwater pollution.

- The development should be kept underground with backfilling of the mined out areas (using excess rock stockpiles).
- The mine should not expand beyond its present size/area of operation.
- The restoration plan should ensure that the area returns to its natural condition. Additional topsoil may need to be brought in for revegetation during reclamation.
- Is the bond adequate to cover the backfilling of mine shafts if the company goes bankrupt?
- The cyanide leaching process should be addressed to make sure new technologies are being considered.
- The road to the top needs to be included in the reclamation, since the visual impact is so severe from the west.
- Blasting may cause structural damage to nearby residences (Heckly's underground concrete water storage tank and concrete septic tank). Company should repair any damage.
- Why has BLM allowed operations to occur without the necessary permits and taxing category?
- BLM should rely on sources other than Echo Bay for their information.
- Echo Bay needs a long range plan for mining and development, since past operations have not met the original claims of the company (e.g., no open pit, 10 years worth of reserves).
- Can the public utility handle the energy requirements of the mine? Are energy conservation measures being considered?

VEGETATION

- Lack of vegetation due to earlier logging may promote (non-point source) runoff from the mine area (impact on groundwater quality).
- Protect timber canopy for mule deer habitat.
- The public land should be restored completely, not just graded and planted with non-native plants.
- Mining activities may impact rare plants such as the headed sedge and trees that suffer from soil compaction.
- Seeding rates should be doubled (in broadcast seedings) to assure germination.

SOILS

- Soil productivity may be one of the greatest impacts.
- Increased sedimentation and erosion potential on the disturbed surface area.
- Erosion control measures and revegetation will be needed to protect soil from erosion during and after county road re-routing.

WETLANDS

- A large pothole wetland exists downslope of the stockpile area of Lamefoot's operation. Precautionary measures are needed to prevent contamination.

TRANSPORTATION

- Mine machinery/heavy equipment may degrade the quality of access roads (to Heckly property).
- Echo Bay should maintain/smooth/improve roads for public transport, including replacement of gravel if necessary.
- Rocks, berms, and clods impede passage on public roads.
- Cross-traffic on Wolfe Camp Road (and other county roads) will deteriorate road surface and require more frequent grading.

6.5 DEISS DISTRIBUTION AND REVIEW

Public Participation

A notice of availability for the Draft Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion was published in the Federal Register on March 11, 1994. This notice announced the beginning of a 60 day public review period ending on May 11, 1994. During this review period one public meeting was held on April 12, 1994 at the Frontier Inn in Republic, Washington.

Copies of the Draft EISS were provided to approximately 220 parties who indicated an interest in the proposed Lamefoot Project. In addition to the general public, a number of public and special interest groups, local governments, tribes, and state and federal agencies received the Draft EISS. The mailing list is available from BLM upon request, and is maintained in the project files.

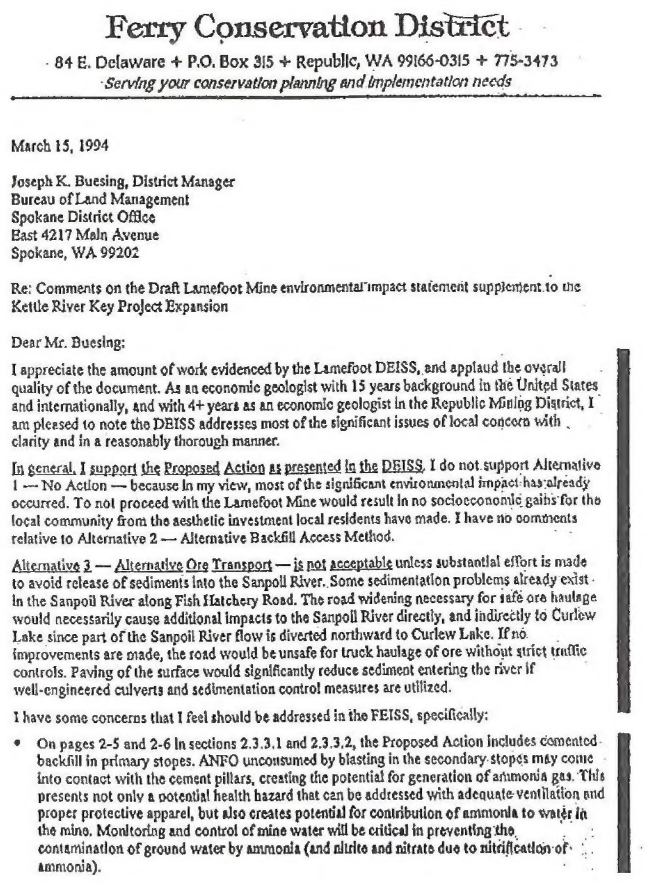
The following pages provide BLM responses to comments received on the DEISS. Comment letters were received and numbered as follows, from the indicated party:

1. Ferry Conservation District
2. Northwest Mining Association
3. United States Department of the Interior, Bureau of Reclamation
4. Max Lewbeal
5. Ray Devlin
6. Reed Heckly
7. Thomas VanKern
8. John Sweetman
9. George M. Stod
10. Dr. E. Adfunidt
11. E. Zahn
12. Department of Community, Trade, and Economic Development
13. U.S. Department of Transportation
14. Tom Johnson
15. Sherry Johnson
16. David Johnson
17. Myron Sawiuk
18. Kettle Range Conservation Group
19. Todd Christensen
20. Susanne Gerde
21. Department of Health and Human Services
22. United States Environmental Protection Agency, Region 10, with EPA rating
23. United States Department of the Interior

Each individual comment in each letter was numbered in the right margin and addressed. Therefore, Letter 8, Comment 2 is designated Comment 8-2. Some comments responses will refer to another response of similar or supplemental content to aid the reviewer. The comment letters and BLM responses are presented on the following pages.

Comment

①



Ferry Conservation District
84 E. Delaware + P.O. Box 315 + Republic, WA 99166-0315 + 775-3473
Serving your conservation planning and implementation needs

March 15, 1994

Joseph K. Buesing, District Manager
Bureau of Land Management
Spokane District Office
East 4217 Main Avenue
Spokane, WA 99202

Re: Comments on the Draft Lamefoot Mine environmental impact statement supplement to the Kettle River Key Project Expansion

Dear Mr. Buesing:

I appreciate the amount of work evidenced by the Lamefoot DEISS, and applaud the overall quality of the document. As an economic geologist with 15 years background in the United States and internationally, and with 4+ years as an economic geologist in the Republic Mining District, I am pleased to note the DEISS addresses most of the significant issues of local concern with clarity and in a reasonably thorough manner.

In general, I support the Proposed Action as presented in the DEISS. I do not support Alternative 1 — No Action — because in my view, most of the significant environmental impact has already occurred. To not proceed with the Lamefoot Mine would result in no socioeconomic gains for the local community from the aesthetic investment local residents have made. I have no comments relative to Alternative 2 — Alternative Backfill Access Method.

1-1

Alternative 3 — Alternative Ore Transport — is not acceptable unless substantial effort is made to avoid release of sediments into the Sanpoil River. Some sedimentation problems already exist in the Sanpoil River along Fish Hatchery Road. The road widening necessary for safe ore haulage would necessarily cause additional impacts to the Sanpoil River directly, and indirectly to Curlew Lake since part of the Sanpoil River flow is diverted northward to Curlew Lake. If no improvements are made, the road would be unsafe for truck haulage of ore without strict traffic controls. Paving of the surface would significantly reduce sediment entering the river if well-engineered culverts and sedimentation control measures are utilized.

I have some concerns that I feel should be addressed in the FEISS, specifically:

- On pages 2-5 and 2-6 in sections 2.3.3.1 and 2.3.3.2, the Proposed Action includes cemented backfill in primary stopes. ANFO unconsumed by blasting in the secondary stopes may come into contact with the cement pillars, creating the potential for generation of ammonia gas. This presents not only a potential health hazard that can be addressed with adequate ventilation and proper protective apparel, but also creates potential for contribution of ammonia to water in the mine. Monitoring and control of mine water will be critical in preventing the contamination of ground water by ammonia (and nitrite and nitrate due to nitrification of ammonia).

1-2

Agency Response

1-1 Your comments are acknowledged.

1-2 See Section 2.3.5 of the FEISS for a summary of the Hydrological Monitoring Plan including sampling for ammonia, nitrite, and nitrates. Supplemental studies for the FEISS included consideration of alternative blasting compounds that will be tested by Echo Bay to reduce the source of nitrate contamination. Mine Safety and Health Administration standards for ventilation minimize the health hazards to mine workers from blasting fumes.

Comment		Agency Response	
①			
I certainly appreciate the good discussion of water treatment alternatives on pages 2-10 through 2-13 in section 2.3.5.4. While I don't necessarily agree with the "dilution is the solution to pollution" concept behind the Land Application option, careful selection of sites may provide benefits to landowners with little potential for negative environmental impacts.	1-3	1-3	Comment noted.
There are some omissions and inaccuracies in the DEISS I would like to bring to your attention; specifically: • At the end of section 3.2.2.1 (page 3-5), a few studies by Ferry Conservation District are referenced. In 1993, the District and Washington State Water Research Center completed a study of water quality in the upper Sanpoil River watershed that is not referenced in the DEISS (Juul *et al.*, 1993). While the Lamefoot Mine is not within the Sanpoil River watershed, ore will be trucked to Echo Bay's mill which is within the watershed boundary. The information in the District-Water Research Center report helps establish baseline parameters prior to trucking Lamefoot ore, and is therefore pertinent to this DEISS. It should be referenced.	1-4	1-4	The document, "Nonpoint Pollution at the Headwaters of the Sanpoil River in Ferry County, Washington" (Juul et al. 1993) was reviewed in writing the DEISS; however, due to an oversight, it was not referenced. It is shown in the current reference list.
• On page 3-6 in section 3.2.3.1 — The discussion of known leaks in the tailings impoundment liner beg the questions of (1) will the additional tails from processing Lamefoot ore increase the potential for renewed leakage, and (2) will the additional tails from processing Lamefoot ore increase the potential for failure of the tailings impoundment? The tailings pond occurs near the Sanpoil River. A major structural failure would impact the river and would also impact Curlew Lake since part of the Sanpoil flow enters the lake. In my opinion, the impoundment must be viewed as a potential point source of pollution. Appropriate emergency response and mitigation plans should be developed to minimize public concern.	1-5	1-5	Potential impacts of the tailings impoundments were evaluated in detail in the 1988 FEIS by the Department of Ecology. Tailings impoundments must meet State dam safety requirements. In the design for the first phase tailings cell, the number of leaks was found to decline as the tailings facility filled. The additional liner in the updated design for the second phase, as approved by the Department of Ecology, would further reduce the potential for leaks. Echo Bay is required to maintain a "Spill Prevention, Control, Countermeasure and Emergency Response Plan" which is regularly reviewed by the Department of Ecology.
• In Table 3.3-1A between pages 3-9 and 3-10, I am surprised at the chloride levels from underground water samples. The work currently underway by Ferry Conservation District reveals relatively pristine surface waters in the Sanpoil River watershed appear to average about 1.0 mg/liter chloride. Chloride is considered a conservative element, persisting in the environment and acting as a good tracer for anthropogenic sources. If this underground water is communicating with surface water, there is potential for misinterpretation that human activities are resulting in pollution. Characterization of surface water in the vicinity is critical.	1-6	1-6	Although the chloride concentrations of underground water samples at the Lamefoot mine shown on Table 3.3-1 are greater than chloride concentrations of local pristine surface waters, the concentrations are not high. The Lamefoot chloride concentrations cited range from 1.27 to 7.3 mg/l. These concentrations agree closely with sample results from wells in the Curlew Lake area (Juul and Funk 1988, Table C-3). The sample results cited in the EISS will also be useful as a baseline from which to measure potential water quality changes due to the proposed mine.
• On pages 3-16 through 3-18 in section 3.5.2 — While Curlew Lake State Park is screened from the Lamefoot site by intervening topography, the only land access to the park is directly across the highway from the Lamefoot site. Park visitors cannot avoid seeing the mine site when the enter and leave the park. In addition, park ranger Jerry Johnson has been developing a trail system in the park for several years. The Lamefoot site is visible from part of this expanding trail system. I suggest Echo Bay commit some resources (funds, equipment and planning expertise) to assist Mr. Johnson in (1) developing the trail system, (2) establishing suitable vegetation to enhance habitat and aesthetics, and (3) assisting with developing a signage system to assist with public education and enjoyment. Mining is a transitory activity, and tourism/recreation will become proportionately more important to the local economy when local mines are depleted. Any actions Echo Bay takes at this time to help assure continuation and growth of tourism and recreation activities, and will represent a meaningful corporate investment in the long-term stability of the local community. Echo Bay's support for the park will also demonstrate a commitment to the local community and will demonstrate the ability of mining operations to coexist with activities traditionally thought of as incompatible with mining. Similarly, Ferry Conservation District owns a substantial parcel on the south end of Curlew Lake. An interpretive nature trail system has been designed for this property but lacks funds. We have discussed the possibility of a connecting trail between our property and Curlew Lake State Park, and the District and Mr. Johnson agree this would be beneficial for all users of these properties. Any investment in these projects would enhance the local community.	1-7	1-7	Echo Bay has worked with the State Parks on several other projects in the past. No additional funding commitments have been secured at the present time.

Comment	Agency Response
①	1-8 Please note that Ferry County is a participating party in the preparation of the EISS. The following table shows the state, county, and local taxes it is estimated that Echo Bay will pay over the expected 6-year life of the Lamefoot project.

- In section 3.11 SOCIOECONOMICS, I do not find any ranking of tax revenues that will accrue to Ferry County as a result of proceeding with the Lamefoot Mine. Considering the increased infrastructure needs to meet the environmental and socioeconomic needs of the community, tax revenues are an important factor in judging the value and impact of this project on the socioeconomic fabric of the community. I strongly recommend this be addressed. Knowing the top ten taxpayers in the County and what they contribute to the County coffers would be helpful, as would a simple comparison of tax revenue impacts if the mine proceeds or does not proceed. Ferry County Assessor John Sweetman has some of this information already available and can assist you with the "what if" scenarios; you can reach him at 775-5204.

  An example of the simple type of comparison I'm suggesting is shown in the following table:

[illegible]	Local revenue [illegible] Project proceeds	[illegible] Project proceeds	Net impact [illegible] local revenue
Ferry County 1% sales and use tax			
City of Republic 1% sales and use tax			
Property tax to Ferry County			
Total			

  This kind of information would be very helpful to the local community in judging the impact of this project on local government and their lives.

1-8

TABLE 1

Kettle River Operations

Estimated Direct Tax Revenues

Lamefoot Project

Description	**Amount ($000's)** State	County	City
Business and Occupational	913[1]		
Payroll	245		
Sales	6,770	532	532
Ad Valorem	600	1,100	
Road Use			
Fuel	93		
Permits/License Fees	84		
Total	8,705	1,632	532

Note:

[1] 3 million tons x 180 x .875 x 375.00 x .00515 (B & O rate)

Assumptions:

- 3 Million tons total reserves (value rounded)
- 6+ Year mine life
- Sales Taxes = 6 years x 1993 taxes with anticipated reduction in costs
- Ad Valorem taxes assumes 6 year mine life decreasing with anticipated reductions in cash flow
- 60 employees
- Seven trucks to be utilized in ore haul

Comment

①

- On page 4-36 — The title of this subsection — OTHER MINES IN THE VICINITY (not owned by Echo Bay) — is misleading. The Republic Mining District proper, and the greater Republic-Curlew area, is riddled with literally dozens of mines. Only a few are active at this time. This historic mining area is nearing the century mark, and the way this subsection is titled fails to recognize the importance mining has had on the local area, and the basis this mining history provides for new operations like the Lamefoot. The title should read: OTHER ACTIVE MINES IN THE VICINITY. **1-9**

Agency Response

Table 2 shows the estimated economic impacts of the Lamefoot mine over the 6-year life of the project. These impacts are based on personal communications with the school superintendent and the Ferry County Assessor, Republic City Planning Office in which it was confirmed that no additional community services would be required as the result of the Lamefoot Project, with the possible exception having to hire one new teacher based on a conservative estimate of 50 new students. Sweetman, 1994, noted that, "it is reasonably clear that the various impacts on schools, community services, courts, law enforcement and various services have already been absorbed and accommodated."

TABLE 2

Kettle River Operations

Estimated Direct Economic Impacts

Lamefoot Project

Description	**State**	**County**	**City**
Highway 21 Road Maintenance[1]	29,400		
Schools - 1 teacher[2]		33,000	
Total	29,400	33,000	

Notes:

[1-] 5 miles x $3500/mi/year x 6 years x 28% total maintenance (Anderson 1994)

[2-] (Lupfer 1994)

1-9 We concur. The change has been made in the FEISS.

Comment	Agency Response
①	
• On page 4-36, regarding Hecla's Republic Unit — While Hecla Mining Company refers to the operation as the Republic Unit, it is called the Knob Hill Mine in Hecla's 10-K report on file with the Security and Exchange Commission. "Republic Unit" refers to an operating property of Hecla Mining Company, whereas "Knob Hill Mine" refers to the ore deposits in the immediate vicinity of Knob Hill that happen to be currently owned by Hecla. Since this section refers to "other mines in the vicinity," and not necessarily to other mining companies, I suggest the property be referred to either as the Knob Hill Mine, or as the Knob Hill Mine (aka Republic Unit). **1-10**	1-10 As verified with a representative from the mine (Devlin 1994), the correct name of the property is Hecla's Republic Unit. Locally, it is referred to as the Knob Hill Mine.
• On page 4-36, regarding Hecla's Republic Unit — The DEISS reports the mine has been "...in nearly continuous operation since approximately 1879 to present." The year 1879 is incorrect. Published histories note the area was opened to mineral entry on February 21, 1896, and the first mineral discoveries were located on February 24, 1896 (Battien, 1989, p.108; Walter and Fleury, 1985, p.26). While gold and silver deposits were known to exist in the area at least a decade before the area was opened to mineral entry, there is no evidence of any commercial ore extraction before 1896. The Knob Hill claim was staked in early 1897 by W.H. "Billy" Kells (Battien, 1989, p.117). Perhaps the author of the DEISS transposed the nine and seven in 1897 to come up with 1879. Also incorrect is the statement of "...nearly continuous operation since approximately 1879...". Production from various deposits occurred during a brief boom in the late 1890s, but most mines were inactive by the time railroads linked the area to regional smelters in 1903. Another boom ensued in 1909 and 1910 due to substantial ore discovered and developed in the Republic Mine. Production following this brief boom was quite sporadic, although some ore was shipped to smelters during the first World War for silica flux. In 1936, surface mining of low-grade ores commenced, and a 500 ton-per-day mill was completed in 1937 to process these ores. Implementation of open-pit mining and the construction of this mill are credited with bringing "...Republic back as a real gold camp" (Anon., 1940, p.7). Although Dayton (1988, p.35) reported "...the Knob Hill mine has been a gold producer more or less continuously since initial production began in 1902..." this is in reference to production from the Knob Hill #1 shaft which dates from 1902. Actual production started when the claim was staked in 1897, and adits were driven to access the ores. Kilburn (1990, p.1) noted the Knob Hill Mine "...has operated on an almost continuous basis since its opening in 1941" but here the reference is to production via the Knob Hill #2 shaft. Production records in Hecla's possession demonstrate that while production from the Knob Hill complex dates from the turn of the century, "nearly continuous" production began with open-pit mining in 1936-7. **1-11**	1-11 Your comment is acknowledged. The changes have been made in the FEISS.

Comment	Agency Response
①	
• On page 4-36, the production rate quoted for Hecla's operations of "...approximately 250 to 300 tons per day" is actually the present mill throughput, and is not necessarily the underground mine production. Underground production commonly exceeds the mill throughput due to the aggregate tonnage of ore and waste mined and hauled. **1-12**	1-12 Your comment is acknowledged and the FEISS has been changed. Devlin, 1994, indicates the production rate is approximately 450 tons per day, 5 days per week.
• On page 4-37 in section 4.15.1, Juul and Funk (1988) found phosphorus loading of Curlew Lake more important in the cultural eutrophication of the lake than nitrate loading. **1-13**	1-13 It is recognized that phosphate loading from other sources contributes to the eutrophication of Curlew Lake; however, nitrates were specifically addressed because nitrates have been identified as a potential problem from the mine.
• On page 4-38 in section 4.15.4 — The statement that "Knob Hill (Hecla Mining Corp) [sic] has operated north of Republic, Washington for over 100 years" is incorrect. First, the correct company name is Hecla Mining Company. Second, the Knob Hill Mine has operated on and off since it was first staked in 1897, so it is (at present) three years shy of the century mark. And third, although Patsy Clark, one of the original 1891 incorporators of Hecla Mining Company, did own part of the Republic Mine in the late 1890s through his ownership of Republic Gold Mining and Milling Company, Hecla did not acquire ownership of any properties in the Republic Mining District until 1981 when Hecla merged with Day Mines, Inc. The wording in the DEISS implies Hecla has been associated with the Knob Hill Mine for a century and this is simply not true. **1-14**	1-14 Your comment is acknowledged.
• On page 4-38 in section 4.15.4 — The statement "In addition, disseminated low-grade gold ore has been extracted by glory hole pits at the ground surface" is only partly correct. As noted above, open pit mining was a primary source of ore in the late 1930s, and these low-grade ores were the primary reason for construction of the Knob Hill mill in 1937. **1-15**	1-15 Comment noted.
• On page 4-38 in section 4.15.4 — In contrasting the Lamefoot ore with Knob Hill ores, Knob Hill veins are described as "...narrow (less than 10-foot wide), isolated high-ore veins at Knob Hill, versus up to 140-foot wide potential veins and disseminated ore bodies at Lamefoot." This description is incorrect. The strike length of the Knob Hill No. 3 vein is 2,660 feet, with a vertical extent of about 1,575 feet, and the entire Knob Hill vein system is about 4,000 feet long with a vertical extent of about 1,700 feet (Salzer, 1990, p.57 and p.63). While bonanza zones often occurred in isolated pockets, ore-grade mineralization was generally persistent for several hundred feet along strike. While the average vein width was on the order of 10-feet wide, older miners in the Republic Mining District tell of some stopes with ore across faces more than 50-feet wide. It was these wide ore zones that were mined by square set methods; as the veins narrowed with depth, overhand cut-and-fill methods were generally utilized, although some shrinkage attempts were made at various times in the history of the Knob Hill Mine. **1-16**	1-16 Current vein widths were verified with Hecla (Devlin 1994). Extraction of Hecla's operation is from narrow (10 to 30-foot thick) vein type gold and current production is from the Golden Promise Vein at depths of about 1800 feet.
• On page 4-47 in section 4.16.5 — If testing found the waste rock stockpiles remaining after backfilling to not be acid generating (as implied will be the case based on data presented in section 3.3.3), and if allowed by law, some or all of the waste rock could be donated to various local and state entities for use as inert fill material in construction projects, culvert protection, road cut armoring, and similar uses. Aesthetically, any waste stockpiles remaining after the project will likely be objectionable to local residents and to tourists without unusual mitigation efforts. Removal and use of the material elsewhere would be a permanent solution. **1-17**	1-17 See Appendix E, Section 4.2 of the Reclamation Plan. Some waste rock will remain on the surface after backfilling to recontour around the portal area. This waste rock will be covered with topsoil and revegetated.
• On page 4-48 in section 4.16.8 — I do not agree that "...completely native seed mixtures for reseeding of private lands..." is absolutely necessary. The present political climate argues strongly for an all-native seed mix, but many areas between the Lamefoot and the Echo Bay mill have had non-native grass stands established during earlier years when there were significantly more cattle grazed in this area. Non-native grasses may act as a better nurse crop, or may adapt better to extreme site conditions, than would native grasses. While I applaud the desire to establish native plants, the most important goal of vegetative cover on the Lamefoot site is to prevent soil erosion. Subsidiary goals are wildlife habitat and aesthetics. Protective vegetation may best be established by utilizing a mixture of native and non-native species. I recommend including language that will allow for non-native plant materials. **1-18**	1-18 See Appendix E, Section 2.6.2 of the Reclamation Plan for details on species selection. The approved seed mixture was developed in consultation with the BLM and USFS. All of the species selected are adapted to the environment in the Lamefoot Project area. BLM policy is to attempt to use native species on public lands. Private lands can use a mix of native and non-native species.

Comment		Agency Response	
①			
- On page 4-49 in section 4.16.13 — While monitoring stormwater and site drainage may identify if wetland areas are received excess sediments, monitoring will not protect the wetlands. Other measures should be specified in this section, including the use of silt fencing if monitoring shows the need to protect the wetlands.	**1-19**	1-19	The surface water retention berm has been designed to retain water and sediment in a 100-year storm event. The retention berm will also prevent excess sediments from entering the wetlands from the quarry area.
- In Appendix C, Reclamation Plan — I applaud the interim seeding measure proposed. Not only will this help reduce erosion, it will also help prevent invasion of noxious weeds by pre-empting favorable growing sites. In my opinion, all disturbed areas should be immediately seeded to help reduce erosion and weed invasion.	**1-20**	1-20	Comment acknowledged.
- Finally, I did not see the U.S. Soil Conservation Service referenced as a contributing agency. The SCS has substantial expertise and experience available to aid in the establishment of suitable vegetation on challenging sites. I strongly recommend their expertise be utilized in conjunction with expertise from other agencies during the reclamation process. I appreciate this opportunity to share my opinions and concerns, and to clarify some points in the record. Let me once again say I am impressed with the scope and quality of the DEISS, and generally support the Lamefoot Project. I look forward to reading the FEISS.	**1-21**	1-21	The Soil Conservation Service was contacted during the scoping process and may be consulted as needed during the reclamation phase.

Sincerely,

Tom Salzer

Tom Salzer
Resource Specialist

cc: Patrice Beckwith, District Conservationist, U.S. Soil Conservation Service
Walt Hunt, Superintendent of Technical Services, Echo Bay Mines

References

Anon., 1940, *Knob Hill mill*: Mining World, January, 1940.

Battien, Pauline, 1989, *The gold seekers...a 200 year history of mining in Washington, Idaho, Montana & Lower British Columbia*: Statesman-Examiner, Colville, Washington.

Dayton, S.H., 1988, *Hecla's Republic Unit: small mine packs a big earnings punch*: Engineering & Mining Journal, December, 1988, pp.34-39.

Juul, S.T.J., J.A. Blake, J.O. Davis and T.A. Salzer, 1993, *Nonpoint pollution at the headwaters of the Sanpoil River in Ferry County, Washington*: Report 86 of the State of Washington Water Research Center, Pullman, Washington.

Juul, S.T.J. and W.H. Funk, 1988, *Study of the water quality of Curlew Lake, Washington*: Report 70 of the State of Washington Water Research Center, Pullman, Washington.

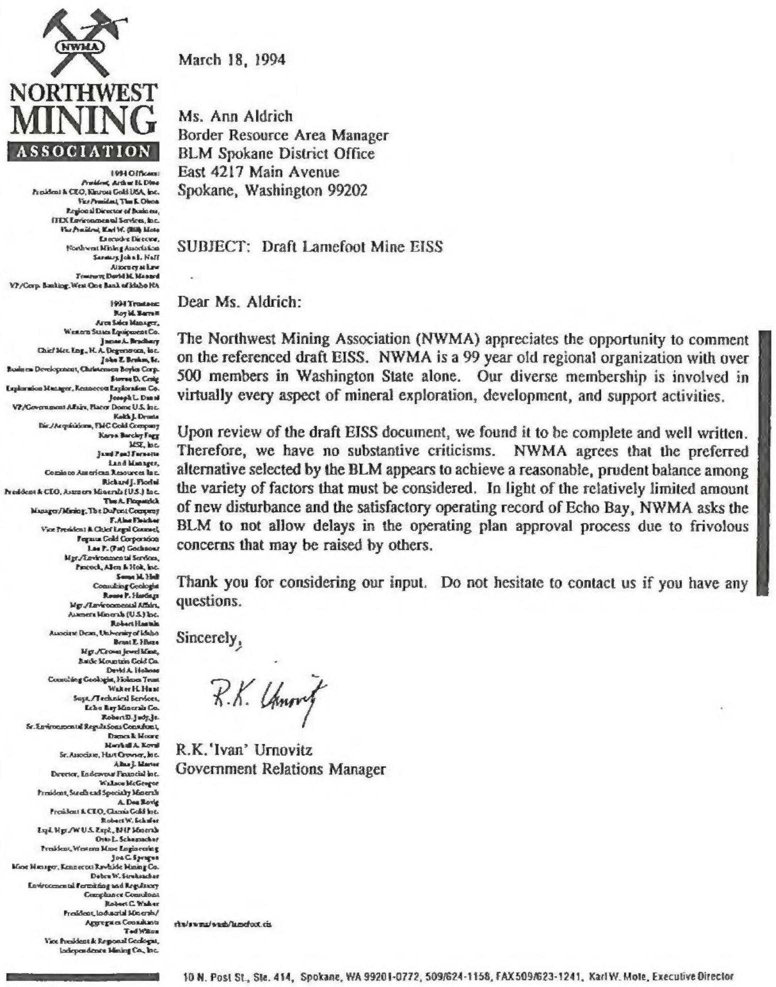
Kilburn, John, 1990, *New decline and drift for Hecla's Republic mine*: The Northern Miner, vol. 75, no. 50.

Salzer, T.A., 1990, *1990 mineral inventory, Republic Unit, Hecla Mining Company*: unpublished intracompany report of Hecla Mining Company.

Walter, E.M. and S.A. Fleury, 1985, *Eureka Gulch: the rush for gold*: Don's Printery, Colville, Washington.

Comment	Agency Response

②



NORTHWEST MINING ASSOCIATION

March 18, 1994

Ms. Ann Aldrich
Border Resource Area Manager
BLM Spokane District Office
East 4217 Main Avenue
Spokane, Washington 99202

SUBJECT: Draft Lamefoot Mine EISS

Dear Ms. Aldrich:

The Northwest Mining Association (NWMA) appreciates the opportunity to comment on the referenced draft EISS. NWMA is a 99 year old regional organization with over 500 members in Washington State alone. Our diverse membership is involved in virtually every aspect of mineral exploration, development, and support activities.

2-1 Upon review of the draft EISS document, we found it to be complete and well written. Therefore, we have no substantive criticisms. NWMA agrees that the preferred alternative selected by the BLM appears to achieve a reasonable, prudent balance among the variety of factors that must be considered. In light of the relatively limited amount of new disturbance and the satisfactory operating record of Echo Bay, NWMA asks the BLM to not allow delays in the operating plan approval process due to frivolous concerns that may be raised by others.

Thank you for considering our input. Do not hesitate to contact us if you have any questions.

Sincerely,

R.K. Urnovitz

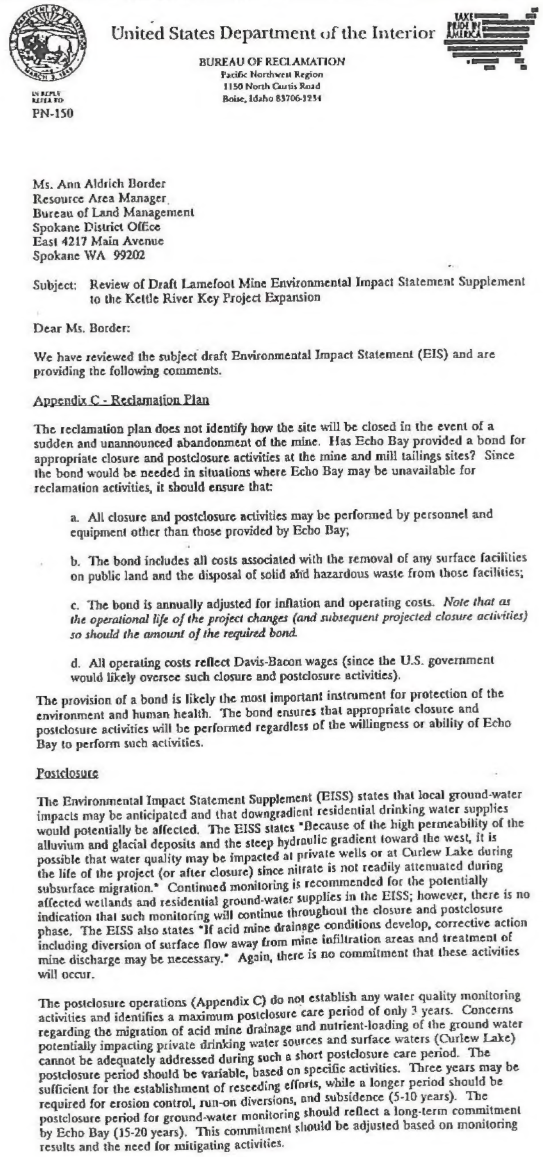
R.K. 'Ivan' Urnovitz
Government Relations Manager

rkn/nwma/wash/lamefoot.cis

10 N. Post St., Ste. 414, Spokane, WA 99201-0772, 509/624-1158, FAX509/623-1241, Karl W. Mote, Executive Director

2-1 Thank you; your comments are acknowledged.

Comment



③

United States Department of the Interior

BUREAU OF RECLAMATION
Pacific Northwest Region
1150 North Curtis Road
Boise, Idaho 83706-1234

IN REPLY
REFER TO:
PN-150

Ms. Ann Aldrich Border
Resource Area Manager
Bureau of Land Management
Spokane District Office
East 4217 Main Avenue
Spokane WA 99202

Subject: Review of Draft Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion

Dear Ms. Border:

We have reviewed the subject draft Environmental Impact Statement (EIS) and are providing the following comments.

3-1

Appendix C - Reclamation Plan

The reclamation plan does not identify how the site will be closed in the event of a sudden and unannounced abandonment of the mine. Has Echo Bay provided a bond for appropriate closure and postclosure activities at the mine and mill tailings sites? Since the bond would be needed in situations where Echo Bay may be unavailable for reclamation activities, it should ensure that:

a. All closure and postclosure activities may be performed by personnel and equipment other than those provided by Echo Bay;

b. The bond includes all costs associated with the removal of any surface facilities on public land and the disposal of solid and hazardous waste from those facilities;

c. The bond is annually adjusted for inflation and operating costs. *Note that as the operational life of the project changes (and subsequent projected closure activities) so should the amount of the required bond.*

d. All operating costs reflect Davis-Bacon wages (since the U.S. government would likely oversee such closure and postclosure activities).

The provision of a bond is likely the most important instrument for protection of the environment and human health. The bond ensures that appropriate closure and postclosure activities will be performed regardless of the willingness or ability of Echo Bay to perform such activities.

3-2

Postclosure

The Environmental Impact Statement Supplement (EISS) states that local ground-water impacts may be anticipated and that downgradient residential drinking water supplies would potentially be affected. The EISS states "Because of the high permeability of the alluvium and glacial deposits and the steep hydraulic gradient toward the west, it is possible that water quality may be impacted at private wells or at Curlew Lake during the life of the project (or after closure) since nitrate is not readily attenuated during subsurface migration." Continued monitoring is recommended for the potentially affected wetlands and residential ground-water supplies in the EISS; however, there is no indication that such monitoring will continue throughout the closure and postclosure phase. The EISS also states "If acid mine drainage conditions develop, corrective action including diversion of surface flow away from mine infiltration areas and treatment of mine discharge may be necessary." Again, there is no commitment that these activities will occur.

The postclosure operations (Appendix C) do not establish any water quality monitoring activities and identifies a maximum postclosure care period of only 3 years. Concerns regarding the migration of acid mine drainage and nutrient-loading of the ground water potentially impacting private drinking water sources and surface waters (Curlew Lake) cannot be adequately addressed during such a short postclosure care period. The postclosure period should be variable, based on specific activities. Three years may be sufficient for the establishment of reseeding efforts, while a longer period should be required for erosion control, run-on diversions, and subsidence (5-10 years). The postclosure period for ground-water monitoring should reflect a long-term commitment by Echo Bay (15-20 years). This commitment should be adjusted based on monitoring results and the need for mitigating activities.

Agency Response

3-1 The reclamation plan for the Lamefoot Mine would be carried out as detailed in Appendix E in the event of an earlier than predicted closure of the mine. Echo Bay will be required to provide the BLM with the estimated costs for closure and reclamation of the Lamefoot Mine. The BLM and the Department of Ecology will make adjustments as appropriate to ensure sufficient financial guarantee is obtained, and the final decision will be detailed in file documents accompanying the Record of Decision.

The financial guarantee for the Key Mill and tailings facility is already on file with the Department of Ecology as part of the overall financial guarantee for the Echo Bay's Kettle River Project. Under an arrangement between BLM and DOE, the DOE will also hold the financial guarantee for all the Lamefoot Mine operations, since most of the activities involve private land. Financial guarantees for Lamefoot would include a cost escalation factor, and cost estimates are based on the work being performed by a contractor, rather than by the government. Although cost estimates are calculated using Davis-Bacon wages, the U.S. government most likely would not directly oversee closure and reclamation under bond forfeiture because the Washington Department of Ecology will hold the financial guarantee. Note that, except for exploration access roads and drill pads, most surface disturbance and all surface facilities involve private land owned by Echo Bay. About 30% of the underground disturbance involves public land.

3-2 To clarify the concerns about the monitoring mentioned in Sections 2.3.4, 4.16.1 and 4.16.2 of the DEISS, the FEISS includes an expanded discussion of Echo Bay's monitoring program. See Sections 3.3, 4.3 and 4.16.3 of the FEISS for details of (a) new geochemistry baseline and impacts issues, and mitigation plans, (b) a water management and control program, and (c) comprehensive hydrologic monitoring plan. In summary, these materials include measures to reduce surface water infiltration and waste water discharge, pollution prevention alternatives, and water quality detection and treatment contingencies, should treatment become necessary. The hydrologic monitoring plan includes monitoring water quality both within the mine and at the permit boundaries for a minimum of ten years post-closure. Water quality monitoring, analysis and interpretation, would be continued beyond the ten years for up to thirty years, or as long as necessary, if test results indicate further monitoring is warranted.

Comment

⑦

Mail to:
Ann B. Aldrich, Area Manager
Bureau of Land Management
Spokane District Office (Border Resource Area)
E. 4217 Main Avenue
Spokane, WA 99202

COMMENTS ON THE DRAFT LAMEFOOT MINE ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT TO THE KETTLE RIVER KEY PROJECT EXPANSION

From visiting with the people at the open house it apears to me that BLM and Echo Bay have done an excellent job trying to take into account any possible problems generated by the Lamefoot Mine. Echo Bay seems to be willing to look at alternative blasting powder to minimize the nitrates and recirculating mine water to decrease the water discharge from the mine.

When the mine is in full production it should decrease the unemployment around Republic and should not effect the tourism industry by taking steps to minimize exposure of the mine.

This seems to be a well engineered and regulated project.

7-1

SIGNATURE: Thomas S. Van Horn

DATE: 4-12-94

Agency Response

7-1 Thank you; your comments are acknowledged.

Comment	Agency Response

⑧

Mail to:
Ann B. Aldrich, Area Manager
Bureau of Land Management
Spokane District Office (Border Resource Area)
E. 4217 Main Avenue
Spokane, WA 99202

COMMENTS ON THE DRAFT LAMEFOOT MINE ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT TO THE KETTLE RIVER KEY PROJECT EXPANSION

THE EIS SEEMS TO REASONABLY ADDRESS THE COMPLETE SPECTRUM OF ISSUES INVOLVED IN AN OPERATION OF THIS SIZE AND CLASS. I UNDERSTAND THAT FURTHER MONITORING WELLS ARE TO BE SHORTLY IN PLACE AND SEVERAL (MINOR) ISSUES OF EFFLUENT WATER QUALITY ARE TO BE REVISED AND IMPROVED.

THE SOCIO-ECONOMIC SECTION OF THE EIS IS REASONABLY COMPLETE AND INCLUSIVE.

THE NET RESULT OF THE PROJECT AS PLANNING IS A NET POSITIVE FOR THE COUNTY AND THE REGION. **8-1**

JOHN SWEETMAN P.O. BOX 586 REPUBLIC

SIGNATURE: ____________ **DATE:** 12 April 1994

8-1 Thank you; your comments are acknowledged.

Comment	Agency Response
⑨	

Mail to:
Ann B. Aldrich, Area Manager
Bureau of Land Management
Spokane District Office (Border Resource Area)
E. 4217 Main Avenue
Spokane, WA 99202

COMMENTS ON THE DRAFT LAMEFOOT MINE ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT TO THE KETTLE RIVER KEY PROJECT EXPANSION

I AM IN FAVOR OF THE BLM ISSUING THE FINAL PERMITS FOR THE LAMEFOOT PROJECT, FOR THE FOLLOWING REASONS:

① ECHO BAY HAS DEMONSTRATED ITS COMMITMENT TO PROTECTING THE ENVIRONMENT OF FERRY COUNTY

2) FERRY COUNTY NEEDS ECHO BAY AS A STEADY INFLUENCE IN EMPLOYMENT.

3) THIS PROJECT IS AN EXCELLENT EXAMPLE OF MINING "THE RIGHT WAY" AND CAN CONTINUE TO BE ONE.

④ THE IMPACT ON THE ENVIRONMENT WILL BE ALMOST NON-EXISTANT.

9-1

SIGNATURE:

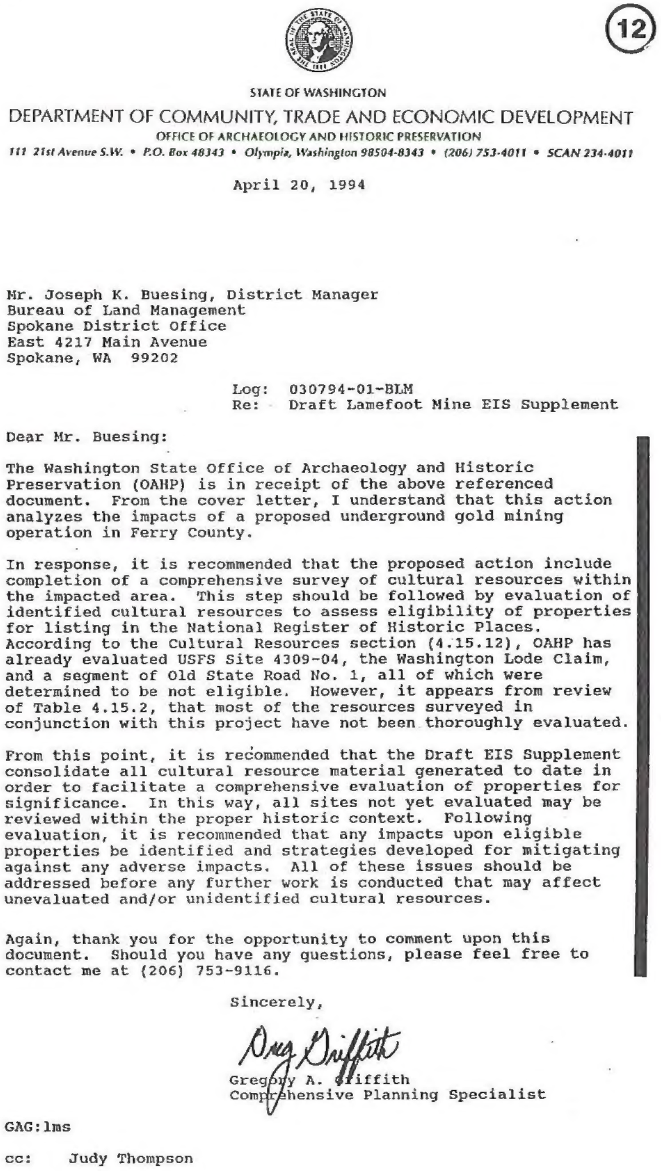
DATE: 4/12/94

9-1	Thank you; your comments are acknowledged.

Comment		Agency Response
Mail to: Ann B. Aldrich, Area Manager Bureau of Land Management Spokane District Office (Border Resource Area) E. 4217 Main Avenue Spokane, WA 99202 ⑩ COMMENTS ON THE DRAFT LAMEFOOT MINE ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT TO THE KETTLE RIVER KEY PROJECT EXPANSION After reviewing the information presented by Echo Bay during a public meeting in Republic, WA on April 12, 1994, I see no reason why the company should be denied a permit to mine the Lamefoot deposit. The company will comply with all State and Federal rules and regulations to safeguard the underground mining operation, and to avoid environmental degradation of the surrounding area. The operation will be an economic benefit to the people in Republic and Ferry County which is badly needed in these difficult times. I hope that your decision will be a positive one when you finalize the EIS on the Lamefoot mine. SIGNATURE: Dr. CASchmidt DATE: April 12, 1994	**10-1**	10-1 Thank you; your comments are acknowledged.

Comment			Agency Response
⑪ D. Dean Bibles, Director Bureau of Land Management PO Box 2965 1300 NE 44th Ave Portland, Oregon. 97208			
1. Lamefoot Mine Expansion EIS Okanogan County, Washington. How about cleaning up old operations? under reclam Are there many old methods involved? Are there procedures which leave debris and devastation? Are you sure an expansion is called for before ascertaining old problems have corrections?	11-1	11-1	Segments of Echo Bay's Kettle River Operations are currently undergoing reclamation in accordance with permits and current reclamation methods. The Lamefoot Mine is not an expansion, but a new project as part of the Kettle River Operations. Appropriate mining and reclamation permitting for the underground mine and backfill quarry is being undertaken by Echo Bay with federal and state authorities.
2. Thank you for ecosystem management approach for BLM and USDA Forest Service lands.	11-2	11-2	Your comment is acknowledged.
3. Will you please insist on ecosystem also (not Northern Spotted Owl approach alone) if old-growth is involved and also please protect Late Successional. Thank you!	11-3	11-3	The BLM and Forest Service propose to develop and adopt a coordinated ecosystem management strategy for all the public lands they manage east of the Cascade Mountains in Oregon and Washington. The purpose of this strategy is to carry out President Clinton's mandate of July 1993 to develop a scientifically sound and ecosystem-based strategy for management of these lands. The strategy will be developed through an environmental impacts statement process referred to as the Eastside EIS which examines a wide range of alternatives.
E. ZAHN 295 Fleet Port Ludlow, WA 98365			

Comment



⑫

STATE OF WASHINGTON
DEPARTMENT OF COMMUNITY, TRADE AND ECONOMIC DEVELOPMENT
OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION
111 21st Avenue S.W. • P.O. Box 48343 • Olympia, Washington 98504-8343 • (206) 753-4011 • SCAN 234-4011

April 20, 1994

Mr. Joseph K. Buesing, District Manager
Bureau of Land Management
Spokane District Office
East 4217 Main Avenue
Spokane, WA 99202

Log: 030794-01-BLM
Re: Draft Lamefoot Mine EIS Supplement

Dear Mr. Buesing:

The Washington State Office of Archaeology and Historic Preservation (OAHP) is in receipt of the above referenced document. From the cover letter, I understand that this action analyzes the impacts of a proposed underground gold mining operation in Ferry County.

In response, it is recommended that the proposed action include completion of a comprehensive survey of cultural resources within the impacted area. This step should be followed by evaluation of identified cultural resources to assess eligibility of properties for listing in the National Register of Historic Places. According to the Cultural Resources section (4.15.12), OAHP has already evaluated USFS Site 4309-04, the Washington Lode Claim, and a segment of Old State Road No. 1, all of which were determined to be not eligible. However, it appears from review of Table 4.15.2, that most of the resources surveyed in conjunction with this project have not been thoroughly evaluated. **12-1**

From this point, it is recommended that the Draft EIS Supplement consolidate all cultural resource material generated to date in order to facilitate a comprehensive evaluation of properties for significance. In this way, all sites not yet evaluated may be reviewed within the proper historic context. Following evaluation, it is recommended that any impacts upon eligible properties be identified and strategies developed for mitigating against any adverse impacts. All of these issues should be addressed before any further work is conducted that may affect unevaluated and/or unidentified cultural resources.

Again, thank you for the opportunity to comment upon this document. Should you have any questions, please feel free to contact me at (206) 753-9116.

Sincerely,

Greg Griffith

Gregory A. Griffith
Comprehensive Planning Specialist

GAG:lms

cc: Judy Thompson

Agency Response

12-1 There appears to be a misunderstanding regarding the primary project addressed by the EISS document which is the Lamefoot Mine in Sections 4 and 9 of T 37 N, R 33 E. This property was surveyed by archaeologists preceding any impacts and a survey report was submitted to the SHPO's office (Log 1942-F-BLM 10). The report submitted by the contracted archaeologists indicated that they did not locate any significant cultural resources within the proposed area of the Lamefoot Mine. The SHPO concurred that there were no significant properties that would be affected by the proposed undertaking (c.f. letter of 2 July 1992).

Various mining and milling projects were briefly reviewed in the Cumulative Impacts section (4.15) of the Environmental Consequences chapter (4.0). Most of the minerals projects addressed in this section have been built and in some cases the mines have even closed. A number of these projects were on private, state or non-BLM federal lands where the BLM did not have, and does not presently have, the authority to implement National Historic Preservation Act (NHPA) requirements. The Cumulative Impacts section was included to provide a context for the evaluation of the present project. Thus, an attempt was made to determine the number and kind of local activities which may have impacted cultural properties to date; it was hoped that this context would shed light on the present proposed operations. In all cases in which the BLM did have NHPA authority, complete adherence to the historic preservation laws were undertaken preceding any impacts to cultural resources.

Comment	Agency Response
U.S. Department of Transportation Office of the Secretary of Transportation 400 Seventh St., S.W. Washington, D.C. 20590 APR 13 1994 ⑬ Ms Ann Aldrich Border Resource Area Manager Spokane District East 4217 Main Avenue Spokane, WA 99202 Dear Ms. Aldrich:	
This office has reviewed the draft Lamefoot Mine environmental impact statement supplement to the Kettle River Key Project Expansion FEIS. We have no comments to offer. Thank you for the opportunity to review this draft EIS. **13-1**	13-1 Thank you; your letter is acknowledged.
Sincerely, Eugene L. Lehr Eugene L. Lehr Chief, Environmental Division	
Tom Johnson 1962 Toroda Ck. Rd. Wauconda, Wash. 98859 22 April, 1994 ⑭ Ann B. Aldrich B.L.M. - Border Area Spokane, Wash. Dear Mrs. Aldrich:	
Regarding Echo Bay's Lamefoot D.E.I.S., I believe their preferred alternative best meets sensible goals and community needs. **14-1**	14-1 Thank you; your comment is acknowledged.
Sincerely, Tom Johnson	

Comment	Agency Response
Mail to: Ann B. Aldrich, Area Manager Bureau of Land Management Spokane District Office (Border Resource Area) E. 4217 Main Avenue Spokane, WA 99202 ⑮	
COMMENTS ON THE DRAFT LAMEFOOT MINE ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT TO THE KETTLE RIVER KEY PROJECT EXPANSION	
Let Echo Bay get on with mining the Lamefoot property. This is my only comment. **15-1**	15-1 Thank you; your comment is acknowledged.
SIGNATURE: Sherry Johnson DATE: April 22, 1994	

Comment	Agency Response
⑯	
Mail to: Ann B. Aldrich, Area Manager Bureau of Land Management Spokane District Office (Border Resource Area) E. 4217 Main Avenue Spokane, WA 99202	
COMMENTS ON THE DRAFT LAMEFOOT MINE ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT TO THE KETTLE RIVER KEY PROJECT EXPANSION	
If Echo Bay can take that hillside and make a mine to help them and the community why dont you let them do it. **16-1**	16-1 Thank you; your comment is acknowledged.
SIGNATURE: David Johnson DATE: 4/23/94	

Comment		Agency Response
Mail to: Ann B. Aldrich, Area Manager ~~(353)~~ - ~~(2647)~~ 356 - 1275 Bureau of Land Management Spokane District Office (Border Resource Area) E. 4217 Main Avenue Spokane, WA 99202 ⑰ **COMMENTS ON THE DRAFT LAMEFOOT MINE ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT TO THE KETTLE RIVER KEY PROJECT EXPANSION** I have received the draft Lamefoot EIS supplement to Echo Bay's Kettle River Key Project expansion. What is clear from this study is that the preferred alternative for ore extraction has been evaluated in exhaustive detail. The facts and engineering proposals clearly show the project to represent a very economically viable enterprise. Impacts as presented are completely minimal which includes insignificant effects on groundwater and wildlife. What is even more compelling is that the irreversible and irretrievably committments of resources are either very localized or not applicable. Based on the above & the rest of the supportive data in the draft it is clear the proposal has met all reasonable requirements for public input and operational safety and design. Therefore the proposal should be given immediate follow-up consideration and be awarded all the necessary permits to allow mining to begin. I have saved my last comment for the authors & contributors of the report. The document is extremely well written which makes the general publics tasks of considering the many complex technical and regulatory passages more manageable. Such efforts are to be commended as they allow for the rapid appreciation of the thorough engineering design and high safety standards for the preferred alternative for the Lamefoot project. SIGNATURE: DATE: May 6, 1994 Star Route 85 Oroville, WA 98844	17-1	17-1 Thank you; your comments are acknowledged.

Comment

⑱

Kettle Range Conservation Group
P.O. Box 150
Republic, WA 99166

Ann Aldrich
Border Resource Area Manager
BLM Spokane District Office
East 4217 Main Ave.
Spokane, WA 99202

May 5, 1994

Dear Ms. Aldrich,

Please accept these comments as part of the public record for the Lamefoot Draft EIS. These are some of the concerns to be addressed during the supplemental EIS process - we would like responses to this input. It must be noted that while some of the concerns from the letter of a year ago on the supplemental EIS were mentioned as part of the public process, concerns were not specifically answered in the Draft. We are therefore enclosing the original questions, and would like to see these and others commenters have their questions specifically answered in the Final EIS.

In addition, here are a few more comments for your consideration.

1. Ore Transportation: The KRCG supports the proposed haul route that would avoid the lower portion of Fish Hatchery Road, and supports the efforts of the residents along the road to contro industrial traffic. **18-1**

2. Socio-Economic analysis: The boundary's of your analysis are unclear. On one hand there is mention of the economic benefit of 43 jobs maintained or created (Draft 4-29). What is a "high beneficial impact". Does this come from a cost-benefit analysis?

3. The section on taxes is incomplete - a breakdown of specific taxes, paid by Echo Bay, on the Lambefoot project is needed. Also needed is the value of the gold that is extracted and processed. Then the $3700 in State B&O taxes, and $630,000 in property taxes (from all Echo Bay operations) can be put in perspective. Income to workers does not necessarily translate into 100% community spending. Mine workers have a positive benefit to the community by spending their dollars locally, and being outstanding citizens. This plus should be weighed against the infrastructure and services that a temporary workforce require. **18-2**

4. The Washington State Metal Mining Act requires a socio-econonmic analysis - will the BLM follow the intent of this new law and do a thorough analysis?

5. The Draft 3-29 shows a drop in visitors from 1991 to 1992 (construction started at Lamefoot) of nearly 20%, no analysis of this trend is noted. Perhaps the Park didn't notice any affect on customers because the ones who didn't stay didn't tell the park. 16,000 visitors spending $100 each in Ferry County amounts to $1.6 million, is it possible those visitors don't like vacationing next to an industrial site? **18-3**

6. NEPA requires a cumulative effects analysis of significant impacts. The K-2 project is mentioned throughout the Draft, yet the impacts of continual tailings production at the mill site are not mentioned. If continual employment is a desired goal and future projects are included in the s-e analysis then the impacts of creating more and more tailings should be weighed. **18-4**

7. Tailings from the Lamefoot ore: The placement of tailings from the Lamefoot project is tiered to the original Key Mill EIS. However, new information, I.E. the Washington State Metals Mining Act (MMA), requires an analysis of siting criteria and the use of All Known and Reasonable Technologies (AKARK). Since the original EIS was done 5 years ago, it seems prudent for the BLM to review the tailings facility, and see how the MMA fits in. AKART is now a double line facility with leak detection between the layers, it too must be considered for the tailings that are generated from the BLM approved project. Otherwise the BLM is likely to be held liable for any damages resulting from the Lamefoot tailings. **18-5**

8. Acid Mine Drainage: Discussion with Walt Hunt at a recent meeting on the K-2 project indicated that the Lamefoot project has relatively high levels of sulfides and therefore acid-mine drainage. While the Draft discusses this potential, and outlines mitigation, it is not clear to the layman whether this will really work or is an untried experiment. In the Draft, Appendix A-25, the prevention and reaction of AMD is discussed. Two areas of long term concern that the BLM should consider are:
   a. Will the groundwater seepage and assumption of highly alkaline groundwater be tested after the project is closed down. AMD often takes years, or even decades to manifest itself. Bonding sufficient to ensure testing for at least 25 years should be obtained from Echo Bay. **18-6**
   b. The reaction rate of the neutralization capacity of the limestone is critical, the chemical reaction on A-25 merely shows one potential chemical reaction and does not portray the dynamic process. While it certainly appears that the quantity of neutralizing material (limestone) is available, and that the "reaction halo" is sufficiently large, the BLM and public should assure themselves by an independent look at this process.
   c. Will the highly alkaline water in the mine cause a problem to nearby groundwater?

Agency Response

18-1 The comment is acknowledged.

18-2 See also response to comment 1-8.

A high beneficial impact, as defined for this EISS, is a major or significant impact that is positive and improves the situation for the socioeconomic resource. See Section 4.0, pages 4-1 (explaining the impact methodology), and review pages 4-2b through 4-30 for discussions of adverse and beneficial effects of the various alternatives.

18-3 As noted in Section 3.10.3, the EISS authors contacted the Curlew Lake State Park management (Johnson 1993) regarding the yearly variance in the number of visitors to the park. Park management attributed the decline in the number of visitors between 1991 and 1992 to bad weather, poor fishing conditions, and a sluggish economy. Park officials have received few comments from visitors regarding adverse impacts of the activities at the Lamefoot site; most comments were regarding the noise from the mine at night.

18-4 This EISS for Lamefoot adequately assesses the impacts of increased ore milling activities and tailings generation from this project (as part of the larger Kettle River Operations) in BLM's view. Table 2-8 notes the reasonably foreseeable projection of potential ore and tailings production from the K-2 exploration project.

18-5 BLM understands that some of the AKART criteria were used in original siting decisions and technology development for the Key Mill. Further, the mill is required to meet certain permit performance standards regarding its operations. Review of the facility design and permit renewals for waste discharge are the responsibility of Washington Department of Ecology (DOE). Since 1989, the DOE has approved upgrades in the cyanide destruction technology used at the mill and modification of the liner design for the tailings facility. The DEISS and FEISS identify these changes and also make recommendations on the monitoring program for the mill. DOE will use this EISS document as part of the basis for further permit reviews.

18-6 See the revised Section 2.3.5 and Section 4.16.3 of the FEISS for details regarding post-closure water quality monitoring and mitigation. To summarize these details, water quality within the mine and at the permit boundaries would be monitored for a period ranging from at least ten years to as much as 30 or more years post-closure. Water quality monitoring will be intensified if test results indicate conditions of concern are developing. In addition, if at any time water quality levels exceed

Comment	Agency Response
⑱	predetermined parameters, appropriate regulatory agencies may initiate any of a number of water treatment options. Echo Bay is required to provide the BLM with an estimate of the cost for closure and reclamation of the Lamefoot Mine. The BLM and the Department of Ecology will make adjustments as appropriate to ensure sufficient financial guarantee is obtained. Final decisions will be summarized in the Record of Decision.
9. We would like to see a qualified expert from the BLM or Bureau of Mines examine this data and proposal, and sign a letter stating that the Acid Mine Drainage problem will be negigible. We would also like you to consider consultation with a third-party expert, not involved in the mininng industry, examine and report on this information. NEPA requires accurate scientific analysis - the BLM must insure itself and the public that this has occurred. **18-7**	18-7 See Sections 4.1.2 and 4.2.1 of the EISS. This document was written by Woodward-Clyde Environmental Consultants, a team of third-party experts in EIS preparation, with technical direction from and consultation with the BLM in Spokane,Washington, Denver, Colorado, Portland, Oregon, and the Washington Department of Ecology and Division of Natural Resources.
10. NEPA process: It is obvious that this project has been tacitly approved - Echo Bay has been removing 300 tons per day of ore for over a year at the Lamefoot project, despite the Draft just not ending comment period. It appears as though the BLMk has violated the requirements of NEPA: NEPA procedures must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA (40 CFR 1500.1(b)). **18-8**	18-8 An Environmental Assessment for the Lamefoot Project Proposed Drilling Exploration Program was completed in June 1992 and approved in the BLM Decision Record dated July 28, 1992. This EA included the exploration drilling program and underground exploration activities that have been conducted to date. Only ore and waste necessarily excavated to create exploration or development mine openings was removed during the exploration phase. As required by the decision "no mining or production from Federal lands is authorized under this decision." In addition, Echo Bay obtained all federal, state and county permits required for the exploration and pre-development activities.
11. Adequate bonding is still a significant issue. Long term monitoring and reclamation may be necessary, the public deserves to know who and how this will be paid for. Finally, here are our comments that were submitted previously. Issues such as a worst case scenario were not addressed, please respond this time to these concerns. **18-9**	18-9 See responses to comments 3-1 and 18-6.
1. The exploratory phase is said to be removing 500 tons per day of ore. This ore is being processed at the Key Mill. This 'exploration' is said to continue until spring 1994. This is a commercial mining production on a scale that is significant, why has the BLM allowed this to occur without the necessary permits and taxing category? **18-10**	18-10 See response to comment 18-8.
2. How will the BLM serve the interests of the 90% of the residents of this county who will be receiving no benefits from this or any mining projects in the county (any increased tax money will be spent on providing services for the temporary, high need, mining community). The recent public open-house appeared to be a conflict of interest, since the lead agency (BLM) was receiving all their information from the permitee (ECHO Bay). How can the BLM reach an independent decision with this type of process? **18-11**	18-11 See responses to comments 3-1 and 18-6. It was verified with the Ferry County Assessor (Sweetman 1994) that the mining community has already been established and community services are in place. The Echo Bay Lamefoot Mine would provide a larger tax base for such things as schools. Echo Bay has or will, through existing written agreements, provide funds to the County for road improvements and maintenance for Old Kettle Falls Road, and will provide funding for the design and relocation of Wolfe Camp Road. Also, due to this project, Ferry County will receive State money to improve Highway 21, which will benefit the entire community after the Lamefoot Mine ceases operations. In addition, Echo Bay has contributed funding to other community services that do not necessarily benefit Echo Bay in the short-term, but will have long-term benefits for the community.

Comment	Agency Response
⑱	The Public Meeting was conducted by the BLM, with Echo Bay providing input regarding their Plan of Operations (i.e., details on how they intend to conduct the operation). However, the EISS was written by the BLM and Woodward-Clyde. Project details and mitigation commitments were verified with Echo Bay as necessary. However, BLM and Woodward-Clyde conducted an independent impact analysis of the Lamefoot Project.
At the public hearing in Republic, Washington, in August 1988, Echo Bay Project Manager Brian Labadie told the audience that they would not open-pit mine! Now all of their ore for 1993 is coming from two open-pit mines. He also said that the reserves at the Kettle River and Overlook mines would last about 10 years - yet four years after the mill opened they are out of production and new projects are prematurely taking their place. Does Echo Bay have a long range plan for mining and development in Ferry County? There is enough concern about this project by residents to merit a more careful and thorough study of socio-economic impacts. **18-12**	18-12 The public hearing held by the Department of Ecology in Republic, Washington, in August 1988 was to specifically address the Kettle Mine, the Overlook Mine and the Key Mill. Both mines are underground operations. Both closed earlier than expected, due to lower quantity and quality of ores than had been predicted, and a drop in gold prices. A recent increase in gold prices has allowed for reopening the Overlook, Mine, with limited production, in order to feed limited ore to maintain Key Mill operations. At the time of the 1988 meeting, mineralization at the Key East and West sites was not considered to be economic. In 1992, economic conditions allowed for development of the Key East and West Mines. A small amount of ore at the Key West Mine may also be accessed by underground operations prior to closure of that mine.
3. What evidence is there to ensure that the Lamefoot Project and future projects will not add to the cumulative effects of ore processing and acid drainage problems. For example, the original plan for cyanide use was predicated on the 10 year project life. As the waste rock accumulates, and the tailings pond that the Lamefoot ore adds to, fills, a higher probability of leakage and contamination occurs. What is this probability - what is the status of ground water monitoring in the down gradient direction toward Curlew Lake? **18-13**	18-13 See response to comments 18-5 and 18-6 and see also Section 4.15 and water control and monitoring plan in Section 2.3.5.
4. Page 42 Plan of Operations (POO), states that of half of the boreholes tested, five discharged water, for a total of 2 GPM. The ability of water to access fractures, workings, and underground rivers through bore holes could draw millions of gallons of water through sulfide bearing rocks, leaching out previously stabilized metals. While current pH indicates a slightly alkaline water, the areas of high acid bearing potential would develop a acidity profile over time. Please show a worst case scenario for dissolved solids and acid producing rock so we know the range of contamination that is possible. **18-14**	18-14 Section 2.3.5 explains water management and controls that will be used to minimize surface water infiltration into the mine and discharge of water from the mine. This section describes and diagrams surface water diversion ditches, and grouting of holes, cracks and fractures to minimize surface water infiltration. Section 4.3.2 of this document addresses reasonably foreseeable conditions of mine water quality post-closure. Recall also that Section 4.16.3 describes the planned groundwater monitoring program. Based on these plans and data, BLM will show final mitigation requirements in the Record of Decision.
5. If the BLM approves this project, we insist it be on the written agreement that Echo Bay will not enlarge the area of operation, by open-pits or other significant surface activity. Until operations have been proven safe we do not want more hydrological threats to any of the watersheds affected by the Lamefoot Project. Otherwise your decision will violate **18-15**	18-15 The proposed action identifies the approximate disturbance from expansion of surface facilities and operations, including potential exploration from the surface. Section 2.2 of the EISS explains the alternatives considered but eliminated - including open pit mining. While open pit mining may be more cost-effective, Echo Bay and BLM chose not to pursue the open pit mining method due to extensive surface disturbance, and potential aesthetic, noise, air quality, and water quality impacts. Further, if the Lamefoot mine is permitted as an underground mine, Echo Bay could not revise their plans to include an open pit mine

Comment	Agency Response
⑱	without an amendment to the permit, and a formal environmental review process.
6. Socio-economics: Those local residents who are adversely affected by the surface activity, noise, mining and ore hauling are not measured in the DEIS - even though degrading aesthetic resources is clearly a measurable quantity and can be applied to this setting. No economic value was put on visual impact! To not study the threat to the long term recreation and quality of life for residents and visitors to the Curlew Lake area is an indication that faulty economic analysis is taking place. **18-16**	18-16 Impacts to aesthetic resources (surface activity, noise, mining and ore hauling, visual impacts) are anticipated to occur at the Lamefoot project, as noted in the EISS (Section 4.5). Echo Bay has made certain commitments to mitigate such impacts, and others may be required by BLM in the ROD. One other party, (see Letter 20, Gerde) has commented on visuals and noise impacts from the mine to residents near Curlew Lake. BLM does not agree that a measurable quantity can be placed on aesthetic resources in this instance. Other quantitative considerations, such as mitigation commitments, and perceptions by neighboring residents (for contrast to Gerde, see Letter 5, Ray Darbin), are important here. Further, the Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA), on how to prepare an EIS, state in Subsection 1502.23: "For purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations."
7. The subsidence problem is said to be solved by refilling the holes with limestone taken from a nearby hillside. This is also said to buffer any potential acid rock drainage problems. Is the bond required by the BLM sufficient to pay for this filling of the mine shafts in case the operators go bankrupt? Please show what the cost of this backfilling is and whether it is covered by the bonding. **18-17**	18-17 Backfilling with Wolfe Camp quarry rock is an operations cost which will be included in the financial guarantee for the operations. The quarry mine plan does take into account acid-generating-potential of rock used for backfill. The ROD will require such backfilling if the Lamefoot Mine is approved, with proper reclamation bonding for the Wolfe Camp quarry.
8. All of the positive and negative impacts of feeding unprocessed materials to the cyanide leaching mill should be addressed - for the intended length of the Lamefoot Mine project. For example, new technologies for cyanide destruction/control, such as ozone, should be incorporated into the processing operation of any ore taken from the Lamefoot Project. While we recognize that the Key Mill EIS looked at processing options, that was 5 years ago. Not only has Echo Bay's plans changed, but so have technologies - you cannot just tier the processing of Lamefoot ore to an old EIS. **18-18**	18-18 See response to comment 18-5.
9. Noise. So far, the Lamefoot project has blasted a cone of noise across Curlew Lake up into the Trout Creek Drainage. The affected residents were not compensated for this inconvenience and violation of their private property rights to keep unsolicited noise off their land. Will compensation occur? **18-19**	18-19 No compensation will occur. Most other scoping comments and letters (except one - see letter 20, Gerde) do not indicate a concern regarding noise. As explained in Section 4.7, noise level monitoring data collected at the site show that noise levels are below the Washington State maximum permissible environmental noise levels. In addition, a number of mitigation measures have already been implemented to decrease the impacts of noise, such as moving fans underground, muffling or enclosing drill rigs, and enclosing the compressor in an insulated building.

Comment	Agency Response
(18)	
10. What if groundwater became contaminated by acid-generating rock drainage from the waste rock or mine, or project causing roadways, parking lots, storage sites in and around the Lamefoot project area? Who will pay for the mitigation required? A specific discussion of how restoration would be done at these sites, or even if mitigation is possible should be presented. **18-20**	18-20 See Section 2.3.5 for the planned hydrological monitoring program for groundwater within the permit boundaries. Section 4.16.3 also addresses mitigation measures that may be taken should the groundwater outside the mine workings deteriorate (post-closure) in quantity and quality and begin to become a concern for domestic well areas or the Curlew Lake vicinity. Echo Bay would be responsible for the costs of any necessary mitigation.
11. A further problem may be the intrusion of dissolved solids into the groundwater. Since local residents have existing use in sub-ground aquifers, this damage should be accounted for in an analysis of the environmental and economic impacts of groundwater contamination. Substantial evidence exists that many groundwater contamination incidents cause irrevocable, or very long term harm. What is the potential for dissolved solid problems. 12. Events in Colorado in the past 2 year point to the need for strict monitoring and bonding. Since Echo Bay has closed two mines in the area, and laid off workers, the BLM should require upfront bonding of the entire cost of mitigation, including a reserve for unforeseen incidents. **18-21**	18-21 See Section 2.3.5 of the FEISS for the planned groundwater monitoring which includes monitoring for dissolved solids. The concepts described in Section 4.16.3 of the EISS would also be used as a basis for financial guarantee requirements. See also responses to comments 3-1 and 18-6.
13. Has the Ferry County mining ordinance been followed? **18-22**	18-22 Yes. The Ferry County mining ordinance requires notification of planned mining activity. It has been verified that a Notice of Operations for the Lamefoot Project is on file with the Ferry County Planning Department (Fritts 1994).
14. Reclamation in the POO (3.11) is said to return the site to historic uses of grazing, logging, and mining, plus wildlife habitat are to be considered. Historically this was part of the hunting grounds of Native Americans, extractive uses are relatively recent. We want the public land part of this project completely restored, not just graded and planted with non-native grass. **18-23**	18-23 The preferred management alternative for public land in the project area, as defined in the Final BLM Resource Management Plan (1985), is recreation, forest and wildlife management. The reclamation plan, Appendix E, meets BLM guidelines and NEPA requirements for reclamation of public land.
15. The question of who is paying for all this analysis and follow-up needs to be addressed. How much money, including staff time, vehicles, computer time, etc. will the BLM spend on the Lamefoot Project. **18-24**	18-24 The BLM does not track the costs involved in reviewing and oversight responsibilities for individual exploration and mining projects.
16. Please study the economic effects of this project on the non-mining part of the community, including loss of nearby property values, degradation of quality of life for residents and visitors, and increased burden on county infrastructure. **18-25**	18-25 See responses to comments 18-11 and 18-29. The Ferry County Assessor verified that property values in the Lamefoot Project area have not decreased since exploration began at the Lamefoot Mine site. In fact, property values have increased (Sweetman 1994).
17. What direct revenues will the BLM receive from Echo Bay Ltd. **18-26**	18-26 None.
18.The economic trade-offs the implementation of this project is making with regards to locating an industrial operation less than a half mile from the major recreational site in Ferry County must be addressed. Long term effects on surface and sub-surface water quality need to be carefully considered. A worst-case scenario may show that locating this project close to Curlew Lake would have long term impacts. **18-27**	18-27 Impacts to surface water and groundwater are discussed in detail in Sections 4.1 and 4.2 of the EISS.

Comment

(18)

19. Please show a chart with the property taxes paid on the Lamefoot Project since 1988. Also provide an estimate of processed or stockpiled ore from the Lamefoot Project since its inception as an "exploratory" operation. At the recent meeting the Echo Bay personnel seemed to have different stories. The manager said 7000 tons had been processed, Walt Hunt quickly interjected that it was 700 tons. Please independently verify this. **18-28**

20. What is the estimated value of the Lamefoot, based on estimated ore deposits? What is the value of ore deposits on BLM land within the Lamefoot Project? Again, please independently verify this. **18-29**

Thank you for your careful attention to this very significant proposed action. Please respond, in writing, to these questions as soon as possible.

Sincerely,

Mike Pet

Mike Petersen, Mining Coordinator
Kettle Range Conservation Group
Box 150
Republic, WA 99166

Agency Response

18-28 The following table shows property taxes paid on the Lamefoot site since 1988.

Kettle River Operations

Historical Property Taxes

Lamefoot Project

Year	Amount	Description of Payment
1988	$23.72	Amount paid by previous land owners
1989	$23.16	Amount paid by previous land owners
1990	$28.74	Amount paid by previous land owners
1991	$24.95	Amount paid by previous land owners
1992	$150,000.08	Property tax allocated in proportion; Lamefoot reserves/total reserves = 37%
1993	$231,903.84	Property tax allocated in proportion; Lamefoot reserves/total reserves = 48%
Total	$382,004.49	

Note: Based upon the County Assessor's "Income Approach" to assessing value at Kettle River Operations (1992 and 1993).

About 114,000 tons of ore grade material have necessarily been excavated from private and public lands during the exploration phase.

18-29 Estimated value of the ore deposit varies daily with changing estimates of ore reserves during exploration, fluctuating costs of extraction, ore haulage and processing, changes in gold prices and other factors. About 30% of minable reserves, by volume, are located on public land. See Section 2.3.2 of the FEISS.

Comment

(19)

TODD CHRISTENSEN
STAR RT 85
OROVILLE, WA 98844

ANN B. ALDRICH
BORDER RESOURCE AREA MANAGER
UNITED STATES DEPARTMENT of the INTERIOR -BLM
SPOKANE DISTRICT OFFICE
EAST 4217 MAIN
SPOKANE, WA 99202
Via facsimile
re: WMN~130~89~109B
3809 (135)

DEAR Ms Aldrich,

I have recently completed reviewing the draft EIS for Echo Bay's proposed Lamefoot Mine. It appears to me that all parties concerned have done a very good job of evaluating the impact of the proposed mine to people and the environment and feel the socio-economic impacts of the proposed mine far outweigh the "adverse" impacts. Therefore I do not support the no action alternative.

I also support the alternative "Backfill Access Method" for back-filling stopes. I believe the Increased surface disturbance is short term and after mine closure would soon be reclaimed and have minimal visual impact. I like the idea of increased traffic safety stated in this alternative.

I see advantages and disadvantages to the various ore transportation routes and must admit to the various plans as a "six of one, half dozen to the other" scenario and support the "route C" alternative as shown in figure 1-2 of the DEIS.

I feel natural resource extraction is an important part of the local + state economy as well as the economy of the nation. The issue is to do it responsibly + wisely. I think this proposed plan + DEIS shows that mining can be done responsibly + with minimal effects to the environment.

Congratulations on a job well done!

Todd Christ

TODD CHRISTENSEN

19-1

Agency Response

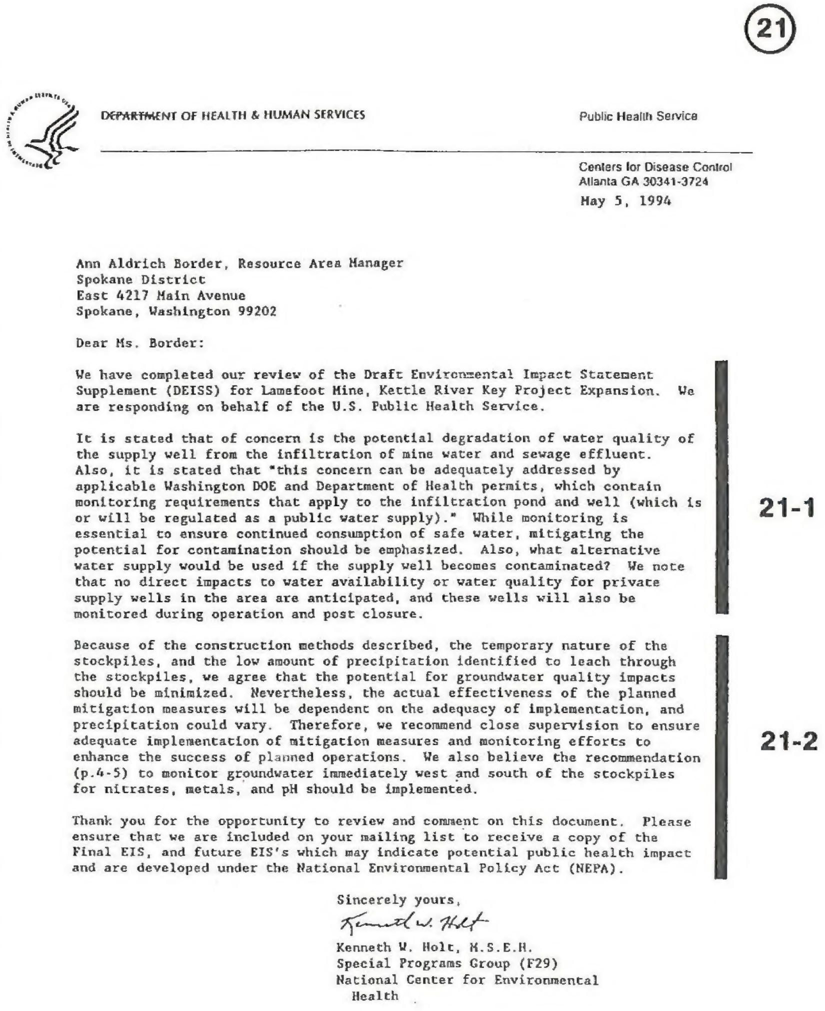
19-1 Thank you; your comments are acknowledged.

Comment	Agency Response
Susanne Gerde 852-16 Pete's Retreat Rd. Republic, WA 99166 (509) 775-3964 ⑳ May 11, 1994 Ann Aldrich, Area Manager Bureau of Land Management Spokane District Office E. 4217 Main Ave. Spokane, WA 99202 Re: Comments on the draft Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion Dear Ms. Aldrich: My concerns relative to the above-referenced project have to do with the following areas:	
1) VRM Classification: I strongly disagree with classification of the "seen" areas s VRM III. This area should be classified no higher than Class II. Because of the project's close proximity to Curlew Lake, it has had a strong negative impact on one of Ferry County's primary scenic resources. The tourist trade attracted to Curlew Lake is very important to the local economy. Also, the water quality of Curlew Lake is at a critical balance, and it won't take much to push it over the edge, which would result in the loss of its recreational, economic and residential value to the county. Also, the mine's location makes it a focal point for travelers along two of the major roads in the county, which also serve a fair amount of international traffic. It's particularly a shame that the siting of the portal and the waste rock piles are in such blatant disregard of VRM standards, as they are the major focus of viewer attention within the "seen" area of the project, but are so disruptive and obvious as to belong only to the "unseen" areas. Section 3.5.2.2 refers to the area as having a high degree of visual sensitivity. I believe this acknowledgment is inconsistent with a Class III VRM designation. **20-1**	20-1 Visual Resource Management (VRM) classes are established by considering the relative value of the scenic resources of an area along with other resource allocation decisions made in the resource management plans (RMPs) for BLM administered lands. The interim VRM classes established for the site reflect the objectives for managing the visual resources and other RMP approved land-use objectives for the project area. In a Class 2 area "contrasts made by human activity should not attract much attention." However, in the immediate vicinity of the Lamefoot Project there are several improvements such as Wolfe Camp Road, Highway 21, the airport, and the nearby residential community. It is because of these improvements that we believe a Class 3 rating is appropriate.
2) Traffic: Page 4-39 refers to the real likelihood of increased traffic along the West Curlew Lake Road, as people try to avoid the increased truck traffic along Highway 21. This will contribute to Klondike Road's already miserable condition coming up out of Republic, and should be mitigated. Also, please consider the possible need to widen shoulders along Highway 21 to protect cyclists from the increased truck traffic. **20-2**	20-2 West Curlew Lake Road (County Rd. 203) is in good condition and has the capacity for an increase in traffic. Travellers staying on State Highway 21 who detour on County Rd. 203 would not necessarily also use the Klondike Road (County Rd. 270). The West Curlew Lake Road joins State Highway 21 via Heron Creek Road on the south and approximately ½-mile north of Curlew Lake on the north. Improvements of the Klondike Road, based on the possibility of some increased use by local traffic as a result of the Lamefoot Project, are not planned at this time. Similar comments at our earlier public meeting suggested this increased traffic may result on West Curlew Lake Road from haulage on Highway 21. The EISS did report this possibility in Section 4.15.6, as the comment notes. However, this detour would result in increased travel distance to avoid haul truck traffic.
3) Noise: I live next to Station #8 of the noise sampling sites. I believe the noise from the mine has a high and adverse impact on our particular area. This may seem inordinately high, but is accurate in light of the peculiarities of the reflective properties of the lake, certain atmospheric conditions (especially in the morning and evening), and the generally bowl-shaped topography of the area. These factors convey the noise to our area at a level that is not reduced in proportion to our distance from the mine. It is especially a problem because of the high contrast between the mine noise and the naturally occurring noise level of the area. This is all born out in the information contained in Table 3.7-1, where peak noise levels at station #8 were very similar to those at the mine itself, especially in the morning and the evening, but the 15 minute average levels were lower, so the higher contrast makes the noise more noticeable. I'm sure the noise from the increased truck traffic will be noticeable, and would recommend that any blasting be done during the middle of the day, as then it seems to blend in more easily with the other noises of the day. (Also, based on Echo Bay's blatant disregard two years ago for regulations and people's need to sleep, as they continued to blast all night long, I'm concerned that they may not comply with the hour limitations for surface blasting now.) **20-3**	20-3 Approximately two years ago, Echo Bay received complaints about the noise from blasting at night. The noise impacts were mitigated when Echo Bay confined blasting to daylight hours, until work had progressed far enough underground that the blasting was not longer audible on the surface. There were no further complaints and it is expected that underground blasting will continue at night. Blasting in the quarry is planned to occur no more than once per week and will be limited to times when traffic is light on the Wolfe Camp Road and only during daylight hours.
4) Vegetation: Will the poplars now planted on a coversoil storage berm along the highway be removed once that coversoil is needed for reclamation? They'll never grow high enough anyway to be a visual screen from the residential area directly across on the west side of the lake. **20-4**	20-4 The trees will remain for the life of the mine, but will be removed when the coversoil is needed for reclamation.

Comment			Agency Response
⑳			
5) Wildlife: You should be aware that bald eagles are very common on Curlew Lake during the spring and fall migratory periods.	20-5	20-5	As noted in Section 3.14, Table 3.14-1, the Northern bald eagle may occur around Curlew Lake; however, within the Lamefoot project area, no suitable nesting or foraging habitat exists for bald eagles.
6) Tunnel under Wolf Camp Rd.: While this sounds like a good idea from a traffic viewpoint, I'm concerned about the amount of groundwater likely to be intercepted by this tunnel, and wonder if grouting may be inadequate and possibly some additional method of protection may be required.	20-6	20-6	Additional measures to control groundwater inflow into the alternative backfill access tunnel, if necessary, are discussed as groundwater mitigation measures in Section 4.16.1 of the EISS. In addition to grouting, lining the tunnel and/or diverting the water flow are suggested as possible means of mitigating infiltration of groundwater into the tunnel. Also, see section 2.4.4 for a discussion of a modified version of the proposed action backfill access.
7) Tailings ponds's effect on groundwater flow: Some references were made to the possible diversion or reduction of waters flowing into the North Fork of the Sanpoil River resulting from displacement caused by the tailings ponds. Section 3.2.2.1, page 3-5 states that "a portion of the Sanpoil River... is diverted north to Curlew Lake. It is not known what percentage of flow goes to each lake." This information relative to percentage of flow is most likely now available in the recent study of the Sanpoil watershed area done by the Ferry Conservation District.	20-7	20-7	The percentage of water flowing into the North Fork of the Sanpoil River is not affected by the location of the tailings ponds. Section 3.2.2.1 is describing the regional hydrology; the bifurcation of flow from the San Poil is a natural phenomenon. See also the response to comment 1-4.
8) ARD and Nitrate levels relative to groundwater: This is probably my primary area of concern. Section 3.1.2, page 3-2 states, "Groundwater flows generally toward Curlew Lake...". I find conflicting statements within the document. Section 4.15.1, page 4.37, states "In the Lamefoot Project area, nitrate loading to groundwater would add to the existing nitrate problem in Curlew Lake". Elsewhere, it is stated that no impact to the water quality of Curlew Lake is anticipated. I believe there is a real possibility that Curlew Lake's water quality may be negatively impacted, which it can ill afford. Of the total hydraulic budget for Curlew Lake, 43% comes from surface and groundwater (Juul and Funk, 1988, enclosed). Information included in the EIS Supplement relates to conditions mostly resulting from exploration, but active mining will result in higher amounts of water inflow, especially the deeper they go, and higher nitrate levels. I would agree with the statement on page 4-4, that "...it is possible that water quality may be impacted at private wells or at Curlew Lake during the life of the project (or after closure), since nitrate is not readily attenuated during subsurface migration". I'm concerned that while DOE's permit sets limits on the discharge pH, it only requires monitoring of nitrate and other water quality parameters for the infiltration pond. I believe acceptable limits should be set relative to these other constituents, also, rather than waiting to become worried until the levels get too high. I'm concerned that this be closely monitored for several years after mine closure also, as it states on page 4-5, "some residual nitrate in the mine and in the backfilled waste rock may continue to leach from the mine".	20-8	20-8	See the response to comment 18-6.
Also, more clastic and other rock types with high AGP will be exposed during active mining. Page 4-2 states, "The rock type exposed on the stope walls and eventually used as backfill would be primarily clastic rock, which has greater acid generating potential and much less neutralizing capacity than the limestone bedrock." I'm concerned about their subsequent contact with water and oxidation, especially since the water seems to show up mostly in fractures where the low grade ore (with high sulfide levels) is crossed by intrusive rocks. Page 4-3 states, "The post-closure discharge from the backfilled workings would probably be dispersed through small fractures in the bedrock, although it is possible that one or more fault or fracture zones of grater permeability may direct the outflow to springs or seeps". What's to guarantee it won't end up in the groundwater flowing into Curlew Lake? I hope there will be diligent enforcement of monitoring and treatment relative to these concerns, both during active mining and post-closure. (By the way, per page C-11, I fail to see how sampling the spring in the Wolf Camp drainage will be a good test for possible acid generation, as the water there is not thought to relate to the faults in the mining area, and it's upstream from the quarry.)	20-9	20-9	The reclamation plan has been rewritten to include the new hydrological monitoring plan; however, sampling of the spring in the Wolfe Camp drainage is pertinent as the water there is likely related to faults in the mining area and it is downstream from the quarry.

Comment	Agency Response
⑳	
Through Walt Hunt at Echo Bay, I've heard of some steps they are now planning that weren't included in this document. The following sound like good ideas, and I hope they are implemented. 1) The use of gel explosives sound as though it may reduce the amount of nitrates that come in contact with groundwater; **20-10**	20-10 Echo Bay is currently experimenting with alternate blasting compounds to address nitrate issues.
2) locating the crusher underground would certainly improve the noise level, especially considering it's planned to be used around the clock; and **20-11**	20-11 Your comment is acknowledged.
3) additional monitoring wells between the site and Curlew Lake should be drilled. **20-12**	20-12 See the response to comment 18-6. The additional monitoring wells have been drilled. See Section 2.3.5 for a description of the monitoring program.
I would like to commend you on some good ideas I found in the document: 1) selection of the borrow area for its minimum visual impact site, and the availability of non-acid generating backfill; 2) care given to choosing rock with a low AGP for use as backfill; 3) ore hauling limited to between 6:30 a.m. and 6:30 p.m.; and **20-13**	20-13 Your comments are acknowledged.
4) per Section 4.16.5, page 4-47, the idea of rock staining sounds like a possible means to reduce the visual impact of the steep and scarred slope above the portal, which appears to be too steep for hydroseeding. It's a major eye sore. Would it be possible to do this now, rather than waiting for reclamation? I was disappointed to see a drawing showing that there would be no attempt to bring this area back to its original grade during reclamation, or even to cover it enough to help it blend in better. I appreciate the opportunity to comment, and look forward to working with you. **20-14**	20-14 Currently, Echo Bay is trying to revegetate this area with grass; however, if this is not successful staining will likely be the next means of reducing visual impacts of the portal area.
Sincerely, Susanne Gerde Susanne Gerde	

Comment	Agency Response



(21)

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
Atlanta GA 30341-3724

May 5, 1994

Ann Aldrich Border, Resource Area Manager
Spokane District
East 4217 Main Avenue
Spokane, Washington 99202

Dear Ms. Border:

We have completed our review of the Draft Environmental Impact Statement Supplement (DEISS) for Lamefoot Mine, Kettle River Key Project Expansion. We are responding on behalf of the U.S. Public Health Service.

It is stated that of concern is the potential degradation of water quality of the supply well from the infiltration of mine water and sewage effluent. Also, it is stated that "this concern can be adequately addressed by applicable Washington DOE and Department of Health permits, which contain monitoring requirements that apply to the infiltration pond and well (which is or will be regulated as a public water supply)." While monitoring is essential to ensure continued consumption of safe water, mitigating the potential for contamination should be emphasized. Also, what alternative water supply would be used if the supply well becomes contaminated? We note that no direct impacts to water availability or water quality for private supply wells in the area are anticipated, and these wells will also be monitored during operation and post closure. **21-1**

Because of the construction methods described, the temporary nature of the stockpiles, and the low amount of precipitation identified to leach through the stockpiles, we agree that the potential for groundwater quality impacts should be minimized. Nevertheless, the actual effectiveness of the planned mitigation measures will be dependent on the adequacy of implementation, and precipitation could vary. Therefore, we recommend close supervision to ensure adequate implementation of mitigation measures and monitoring efforts to enhance the success of planned operations. We also believe the recommendation (p.4-5) to monitor groundwater immediately west and south of the stockpiles for nitrates, metals, and pH should be implemented. **21-2**

Thank you for the opportunity to review and comment on this document. Please ensure that we are included on your mailing list to receive a copy of the Final EIS, and future EIS's which may indicate potential public health impact and are developed under the National Environmental Policy Act (NEPA).

Sincerely yours,

Kenneth W. Holt

Kenneth W. Holt, M.S.E.H.
Special Programs Group (F29)
National Center for Environmental
Health

21-1 The primary purpose of the supply well is to provide water for underground mining operations (e.g., drilling). However, the supply well is regulated as a public drinking supply and the proper permits are in place and the water is monitored as required. Should the water become contaminated; however, Echo Bay keeps a supply of bottled water on site for drinking purposes. If private wells outside the project area become contaminated either during or after mining operations, an alternative source would need to be identified and provided.

21-2 Section 2.3.5 of the FEISS provides details on the hydrologic monitoring plan, which includes monitoring points south and west of the stockpiles. The additional wells have been installed and will be used to monitor ground water quality both during operations and post-closure.

Comment	Agency Response

㉒

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

RECEIVED
MAY 20 94

MAY 13 1994

REPLY TO
ATTN OF: WD-126

Joseph K. Buesing
District Manager
Bureau of Land Management
Spokane District Office
East 4217 Main Avenue
Spokane, WA 99202

Dear Mr. Buesing:

The Environmental Protection Agency (EPA) has reviewed the draft Environmental Impact Statement (EIS) for the **Lame Foot Mine, Supplement to the Kettle River Key Project Expansion** located in the Border Resource area, Washington. Our review was conducted in accordance with the National Environmental Policy Act (NEPA) and our responsibilities under Section 309 of the Clean Air Act.

This draft EIS evaluates the no action alternative and three action alternatives for a proposed underground gold mine located near Republic, Washington. Ore extraction would be by long hole open stoping mining technique. The ore will be taken to the existing Key Mill for processing. Waste rock will be temporarily stored above ground until completion of the commercial mining phase when it will be used for backfill.

This draft EIS has a number of excellent features. It presents an extensive and comprehensive cumulative effects scenario upon which to base the regional cumulative impacts analysis. Additionally, the characterization of environmental conditions prior to 1992, before exploration began, and current environmental conditions, since exploration began, provides the EIS reviewer with detailed site specific cumulative effects information. Providing a different definition of study area for each resource category allows the impacts analysis to reflect the areal extent of the resource.

Although the draft EIS has several good analyses and features, we have some comments on potential water quality effects.

Comment

(22)

Waste Rock Storage Pile Drainage

The draft EIS describes temporary waste rock storage piles but does not address how mine drainage from these sites will be handled. The final EIS needs to fully describe how drainage from the temporary waste rock piles is/will be collected, treated, and discharged. The final EIS should also provide a characterization of this drainage. **22-1**

Infiltration Pond

On page 2-9, the draft EIS states that excess water is discharged by infiltration at the pond site shown on Figure 2.6. Two infiltration ponds are shown on this figure. The final EIS needs to clarify whether both ponds are used for mine drainage water or whether one is used for mine drainage and the other for stormwater. On page 2-13 the draft EIS discusses the drainage as if acid potential is the only characteristic that would cause this effluent to be regulated as "mine drainage". From a regulatory perspective any drainage that comes into contact with disturbed areas within the mine site is considered mine drainage and must be regulated in that manner. Whether or not the drainage is acidic is not relevant for determining the regulatory category; mine drainage versus storm water. The final EIS should clarify this discussion found in the draft EIS. **22-2**

Surface Water/Groundwater Effects

Pages 4-2 and 4-3 discuss increased potential for acid rock drainage (ARD) from the stope walls and backfill material. Page 4-4 states that if ARD developed it would be difficult to detect and treat after closing the mine and the groundwater could violate Washington groundwater standards - for nitrates in particular. We are concerned about this conclusion. Further, if the ground water monitoring program demonstrates a connection or nexus between mine drainage or storm water drainage from the mine area and downgradient water quality at seeps, springs, wetlands, or Lake Curlew an NPDES permit would be required. **22-3**

The final EIS should demonstrate that drainage from the closed mine could be controlled. The mitigation measures in Section 4.16.1 and 4.16.2 should be committed to in the final EIS and included in the Record of Decision (ROD).

National Pollutant Discharge Elimination System (NPDES) Permit

On page 4-3 the draft EIS says that any seepage of infiltration water from the ponds to wetlands is covered by DOE permit 8033. This constitutes a discharge to waters of the US. The final EIS needs to explain what permit 8033 is. The drainages mentioned on page 4-8 are all mine drainage and as such, any discharge of these into surface waters would need an NPDES permit. The final EIS should also clarify whether waste rock was used for haul road construction. If waste rock is used for road construction any drainage from these roads would be considered mine drainage and would need to be covered by an NPDES permit. If the haul roads are constructed of other materials, are they covered by an NPDES stormwater general permit? **22-4**

Rating

Based on our review, we are rating this draft EIS EC-2 (Environmental Concerns-Insufficient Information). Our environmental concerns are based on the potential adverse effects to surface water and groundwater. We have requested additional information about: required discharge permits, regulatory category for discharges, waste rock pile drainage control, and site specific drainage control plans.

We realize that these comments are late. We hope that these comments can still be used as you prepare the final EIS. We appreciate the opportunity to review and provide comments on this draft EIS. If you have any questions about our review comments please contact Sally Brough in our Environmental Review Section at (206) 553-4012.

Sincerely,

Sally Brough
for
Joan Cabreza, Acting Chief
Environmental Review Section

Agency Response

22-1 Storm water drainage from the waste piles is addressed in the Storm Water Pollution Prevention Plan for Echo Bay Kettle River operations, on file at Lamefoot offices and at the Washington Department of Ecology (NPDES Permit No. 5 03-001184). Water quality characterization of this drainage from the temporary waste pile has not been performed. "Mine waste" water drainage from these piles (given that the material on the surface may be there 1-2 years) will be monitored using the water quality detection and treatment contingency system described in Section 2.3.5 of the FEISS and in comment response 22-3 below.

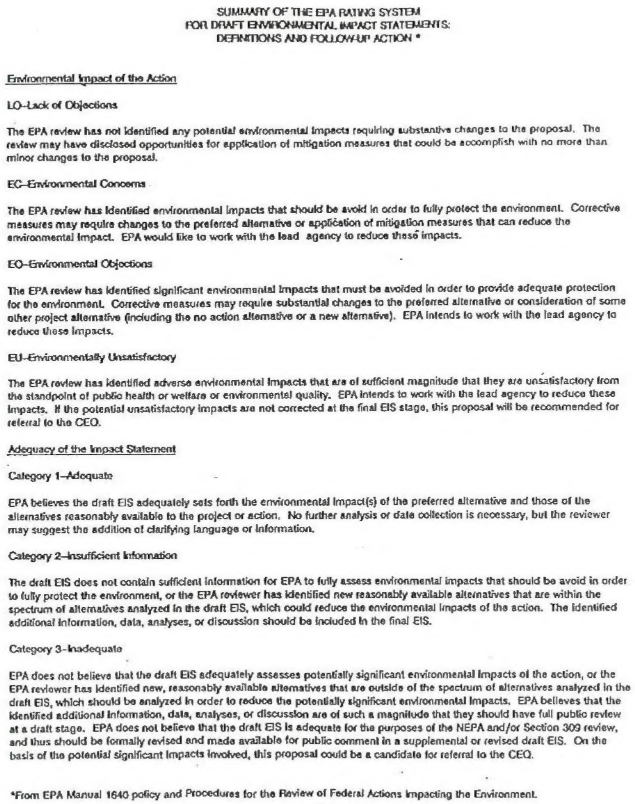
22-2 Refer again to figure 2-6 and note the northernmost pond is labeled "Infiltration Pond" (for mine drainage), and the southernmost pond is labeled "Stormwater Infiltration Pond."

The two-cell infiltration pond addresses mine adit drainage water: one cell acts as the overflow cell for the other. Discharge to the infiltration ponds is addressed under Washington Department of Ecology Waste Discharge Permit No. 8033, as mine drainage water. The storm water infiltration pond addresses only storm runoff water from surface facilities as contained in the water diversion ditch (per the Storm Water Pollution Prevention Plan for the Kettle River Operations).

22-3 The EISS states on Page 4-4 that after mine closure, water quality problems would be more difficult to detect than during active mining because the mine water is diverted to a single point and monitored under a specific permit during active mining. A Hydrologic Monitoring Plan has been developed which includes both active and post-closure monitoring and, if necessary, water treatment. These concerns have been addressed in this plan (see Section 2.3.5 of the FEISS). For nitrate in particular, this constituent should be less of a concern after mine closure because the source of nitrates (i.e., blasting compounds) would no longer be introduced to the mine (see Source Control, Section 2.3.5.2 in the FEISS).

Several measures to control mine drainage are described in revised Section 2.0 of the FEISS, and as recommended mitigation measures in Section 4.16. The comment is noted. Where appropriate, additional commitments by Echo Bay are presented in the FEISS and/or Decision Record. Additional requirements by the BLM are noted in the ROD.

22-4 Washington Department of Ecology Waste Discharge Permit No. 8033 regulates the discharge and monitoring of mine process waters for the Echo Bay Kettle River projects, including the Lamefoot Mine and Key Mill.

Comment	Agency Response
 SUMMARY OF THE EPA RATING SYSTEM FOR DRAFT ENVIRONMENTAL IMPACT STATEMENTS: DEFINITIONS AND FOLLOW-UP ACTION * Environmental Impact of the Action LO--Lack of Objections The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplish with no more than minor changes to the proposal. EC--Environmental Concerns The EPA review has identified environmental impacts that should be avoid in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts. EO--Environmental Objections The EPA review has identified significant environmental impacts that must be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts. EU--Environmentally Unsatisfactory The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the CEQ. Adequacy of the Impact Statement Category 1--Adequate EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or date collection is necessary, but the reviewer may suggest the addition of clarifying language or information. Category 2--Insufficient Information The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoid in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses, or discussion should be included in the final EIS. Category 3--Inadequate EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussion are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ. *From EPA Manual 1640 policy and Procedures for the Review of Federal Actions Impacting the Environment.	Echo Bay also has acquired an NPDES permit No. S 03-001184 that addresses other mine drainage and runoff not specifically covered by DOE permit No. 8033. This permit has been added to Table 1-1 in the FEISS. Waste rock was not used for haul road construction.

Comment	Agency Response

(23)

United States Department of the Interior

FISH AND WILDLIFE SERVICE

MAY 19

Memorandum

To: District Manager, Bureau of Land Management, Spokane, Washington

From: Acting Assistant Regional Director, Ecological Services
Region 1, Portland, Oregon

Subject: Review and Comments to Draft Lamefoot Project Environmental Impact Statement Supplement to the Kettle River Key Project Expansion, Ferry County, Washington (EC94/0030)

ACTION: Joseph K. Buesing, Spokane District Officer

The Fish and Wildlife Service (Service) has reviewed the Draft Lamefoot Project Environmental Impact Statement Supplement (EISS) to the Kettle River Key Project Expansion (Project), Ferry County, Washington. The following comments are provided for your use and information when preparing the final documents.

GENERAL COMMENTS

The Echo Bay Minerals, Inc. (Echo Bay), which is part of the Kettle River River Project, is proposing to produce gold from the Lamefoot Mine mining operation and expand the ancillary facilities. Both the proposed and present mining actions involve seven to 12 acres of Bureau of Land Management managed lands and 38 acres of privately lands.

23-1

Water Issues The Service is concerned about the Project's effects on surface and groundwater flows and potential impacts to the biota which depend on these water sources. We are primarily concerned about the potential impact of the alternative access backfill tunnel on the downgradient spring and wetlands. The alternative access backfill tunnel, as described in the report, would likely intercept groundwater in the saturated alluvium and bedrock fractures. The draft EISS briefly describes mitigation measures, including grouting/lining the tunnel and diverting flows to recharge the alluvium downgradient of the tunnel (Section 4.16.1, item 4). Specific information on how these mitigation measures would be accomplished and the likelihood of success in maintaining groundwater flow to the wetlands is not provided. This information needs to be included in the final documents to assess this alternative.

The only justification provided for construction of the alternative access backfill tunnel is the elimination of traffic control and safety concerns at the intersection of the portal access road and the county road (Section 2.4.2). Impacts from disruption of the groundwater system which supports the spring and wetlands may have a much greater potential effect than disruption of traffic on a road which is used by five residences and receives light recreation use (Section 3.5.2). However, if Alternative 2 is implemented, a plan to monitor wetland hydrology and provide mitigative actions should be in place.

23-2

Cyanide tailings ponds are a well known cause of significant mortality of waterfowl, shorebirds, and other wildlife throughout the west (Clark and Hothem, 1991; Albersworth et al. 1992); yet, the potential impacts of the Key Mill tailings pond to wildlife was not addressed in the draft EISS. Additionally, no information was provided on the concentration of cyanide determined from the permit monitoring program, except that permit requirements were met. It has been documented that cyanide concentrations vary considerably throughout a tailings pond; highest concentrations may occur at the inflow to the pond (Henny et al, 1993). According to informal information from Pat Hallinan of the Washington Department of Ecology, cyanide monitoring samples at this mill are collected from the return line, where concentrations of cyanide would be the lowest. Even though permit requirements are being met, the tailings pond may present a toxic threat to waterfowl and other wildlife. The final document should 1) present data on cyanide concentrations in the tailing pond, 2) assess possible impacts to wildlife, and 3) address cumulative impacts of expansion.

23-3

The Key Mill tailings pond appears to have a significant effect on local groundwater systems, as suggested by the drying up of two nearby monitoring wells and one natural spring. Section 3.1.4 addresses the concerns of other local groundwater users; however, the existence of nearby springs or wetlands and the potential effect to these areas and associated biota are not addressed. Also, the possible cumulative impacts of the tailings pond and water withdrawal from the Echo Bay's wells on nearby springs and wetlands are not addressed. Both of these concerns need to be discussed in the final EISS document.

23-4

The sizes of the infiltration ponds for mine drainage and stormwater runoff was not provided in the draft EISS. We are concerned that waterfowl and other wildlife may be attracted to these waterbodies during periods of inactivity at the mine. The final EISS should address potential wildlife use of the infiltration ponds and associated potential impacts of contaminants to wildlife.

23-1 The EISS identifies potential impacts of the alternative backfill access tunnel that may result depending upon subsurface geological conditions along the tunnel and raises. If this potential problem is realized, several engineering solutions are identified as recommended mitigation measures in Section 4.16.1. Echo Bay is currently conducting geotechnical investigations of this tunnel alignment and has added a new alternative backfill access that is evaluated in the FEISS.

23-2 The potential impacts of the Key Mill Tailings Pond to wildlife were specifically addressed in the 1988 EIS prepared for that site by the Department of Ecology. Washington requires WAD (weak acid dissociable) cyanide concentrations in tailings ponds of 40 ppm (mg/l) or less, which eliminates mortality in most cases. Over the years only a few dead waterfowl have been observed at the Key Mill tailings pond.

Data available from the reclaim pond are representative of conditions since the installation in September 1991 of the INCO SO_2 cyanide destruction system. A sampling of the data from October 1991 to July 1993 show WAD cyanide levels ranged from 0.1 to 53 ppm, with an average of 7.7 (n=203) in the reclaim water at the intake point.

Wildlife mortality is unlikely to occur in the tailings pond as a result of cyanide exposure. Since the most recent available concentrations in the pond are within permit standards, there should be no cumulative impacts of expansion. Since no change to the cyanide destruction process is anticipated the concentrations are not expected to vary.

23-3 The hydrologic conditions at the two monitoring wells and spring are described in the EISS as part of the existing baseline because the local groundwater recharge was reduced with placement of the original tailings impoundment. As a connected action to the proposed project, the existing tailings impoundment will be expanded. No additional adverse impacts to wells and springs are predicted. Additional monitoring was recommended (see Section 4.16. of the FEISS).

23-4 Figure 2-6 with a scale of 1"=200' shows the infiltration pond and storm water infiltration pond are both less than 0.25 acres in size. Given the proximity of Curlew Lake, it is extremely unlikely that waterfowl or most other water-associated birds would be attracted to these ponds. Migrating shorebirds might stop over briefly if no other mudflat type habitat is present in the area, which is also unlikely. These ponds will have water in them only for short periods of time, usually less than a day, before the water infiltrates into the ground. Rapid infiltration will remove any collected water in a short period of time, reducing exposure time to

Comment	Agency Response
㉓	wildlife. The existence of a natural wetland, spring, and stream nearby in an area much more secluded from the disturbance at the mine site will serve as a much more attractive watering area to wildlife and will not reach the storm water infiltration pond. Given the very short period of time water will be available in these ponds for wildlife consumption and the low levels of contaminants present, adverse effects are extremely unlikely. Of the three contaminants of concern (As, Mo, Se), selenium is of most concern should there be fish in the pond, and should those fish be eaten, and the contaminants bioaccumulated by birds. However, such a scenario is likely not possible, the exposure pathway is incomplete. Water quality data given in 3.1.3 Baseline Conditions 1992-93 show that background water quality in the Wolfe Camp alluvium exceeds state groundwater criteria for arsenic, iron, manganese, sulfate, selenium, and total dissolved solids. See Appendix A of the FEISS for a discussion of water treatment methods for water discharged to the infiltration pond from the mine.
The draft EISS indicates that Echo Bay will be studying possible water treatment methods, particularly for nitrates, and that groundwater monitoring will occur. However, no information is provided in the document to indicate what conditions would trigger the construction and utilization of a water treatment system. Monitoring of the mine infiltration ponds indicates that nitrates are already a water quality problem in the exploration phase of the project. Thus, the Service recommends that a water treatment system be brought on line at or before full-scale operation of the mine to prevent contamination of the nearby wetlands, Curlew Lake, and downgradient wells and possible effects to fish and wildlife resources from nitrates and metals. Both the water returned to the mine for reuse and the excess water discharged should be treated. **23-5**	23-5 See Appendix A for revised water treatment methods. Only small amounts of water are discharged by the exploration operations. The Department of Ecology sets the discharge limits. Requirements would be based on the inability of initial control measures proposed by Echo Bay to meet the discharge limits. Agency evaluations will be conducted periodically at closure and during the post-closure period (see Section 2.3.5).
Mitigation The major activity center at the mine site would be located adjacent to some wetlands and a spring. Thus, the mine site would clearly impact wildlife use of the adjacent wetlands and spring, and cause wildlife to avoid the surrounding areas for the life of the project. The spring is an important watering area for wintering deer, and mining activities would reduce or eliminate deer use of this spring. Mitigation for the loss of habitat value incurred for the duration of the project should be provided. Opportunities to provide mitigation in this area during the mining period appear limited. Therefore, the mitigation should be provided following closure of the mine. We recommend placing a conservation easement or deed restriction on the property, specifying that, at the time of closure, the spring, wetlands, and surrounding areas be maintained as high quality wildlife habitat in perpetuity. Additionally, the exclusion of livestock from formerly grazed wetland areas should be continued. **23-6**	23-6 Mitigation provided through removal of livestock grazing is considered to more than offset the adverse effects of mining. Continued elimination of grazing was recommended as mitigation in the EISS. However, a conservation easement or deed restriction in perpetuity would be a restriction of private property rights that is not justified by the impact analysis. See Section 4.14. We concur that there will be some impacts to wildlife. A biological evaluation (FWS Reference #1-3-94-I-136) was filed with the Olympia, WA office of U.S. Fish and Wildlife Service and approved by them on 1/13/94. This evaluation for threatened and endangered species (grey wolf, grizzly bear, bald eagle) also considered impacts to ungulate populations (primarily deer).

Comment			Agency Response
	㉓		
Reclamation The Service recommends that Echo Bay be required to post a performance bond or establish an escrow account to provide assurance that monies would be available for reclamation of the project area.	23-7	23-7	The BLM and the Department of Ecology will ensure that sufficient financial guarantee is obtained for reclamation. Financial guarantee requirements will be identified in the Record of Decision.
Reclamation of the diversion ditches and infiltration ponds needs to be addressed in the final documents. Seeding of diversion ditches was mentioned to reduce erosion. At project closure, diversion ditches should be filled to prevent future uncontrolled erosion. If the diversion ditch infiltration pond develops a dependable hydrology, Echo Bay may wish to allow the pond to remain, or even improve wetland habitat with plantings of native species. This would provide additional habitat diversity to the reclaimed area. Specific plans need to be developed for the closure of the mine infiltration pond. Water and sediment quality problems are likely with this pond, so closure should address limiting movement of contaminants and eliminating potential wildlife exposure.	23-8	23-8	See Appendix E, Figure E-3 and Section 2.3.10 of the FEISS.
SPECIFIC COMMENTS Figure 2-4 A map showing a larger area around the tailings pond including roads, the river, and monitoring wells would be helpful to the reviewer. Line B-B' of Figure 2-5 should be inserted on Figure 2-4.	23-9	23-9	This figure has been replaced. (See new Figure 2-4.)
Page 2-8, Paragraph 1 The use of fly ash should be avoided because of the likelihood of leachable contaminants entering the groundwater. If fly ash is to be used, the source(s) should be disclosed, analysis of leachable components should be conducted, and potential contaminant impacts to groundwater should be assessed.	23-10	23-10	We concur. This issue would be evaluated if the use of flyash is proposed.
Page 2-9, Paragraph 1 Information on monitoring parameters and frequency should be provided.	23-11	23-11	See Section 2.3.5 of the FEISS for details of the new hydrological monitoring program.
Page 2-9, Paragraph 5 Water inflows to the mine may exceed mine needs and pond infiltration capacity, or infiltration capacity may decrease with use of the pond over time. The final EISS needs to address what would happen to excess water if this situation were to occur.	23-12	23-12	Text has been amended. See Section 2.3.5 Water Control, Handling, and Treatment in the FEISS. Periodic cleaning of the infiltration pond is a normal maintenance procedure.
Page 2-9, Last Paragraph Figure 2-3 does not illustrate this information.	23-13	23-13	The figure number has been changed to 2-2.
Page 2-12 While artificial wetlands and land application may be appropriate for treatment of excessive nitrates in waste water, this water may also contain elevated concentrations of trace elements which would accumulate in these systems and possibly impact biota. The final EISS should address this possibility.	23-14	23-14	Plants uptake metals and other nutrients from soils or nutrient solutions through their roots and from aerial sources through their foliage. Roots and foliage can also act as barriers to uptake of elements. Total accumulation by plants depends on many factors including 1.) the nature of plants, such as species, growth rate, root size and depth, transpiration rate, and nutritional requirements, 2.) soil factors such as pH, organic matter content and nature, nutrient status, and amount of metal ions and certain anions like phosphate, sulfate, and sulfides, and clay content and type, 3.) environmental and management variables such as temperature, moisture, sunlight, and amendments and fertilization, and 4.) the modes of metal toxicity and plant tolerance. Given these variables, it is difficult to estimate whether or not plants at the site might accumulate site-related metals. Some accumulation of metals may occur within plants, which in turn may be passed up the food chain as animals feed on the plants. However, it is unlikely that the plants themselves would be affected by excessive metals concentrations since in general, plants are much more resistant to an increased concentration than to an insufficient content of a given element. In addition, it is unlikely that animals would be affected since any birds or mammals that might feed at the wetlands near the site are likely occasional visitors with other primary food sources since the wetlands are relatively small. The high level of human activity at the wetland locations would further preclude frequent wildlife use of the area.

Comment	Agency Response
㉓	
Page 2-16. Section 2.4.1. This section should include information on reclamation of areas disturbed during exploration. **23-15**	23-15 The Reclamation Plan, Appendix E of the FEISS addresses reclamation of the disturbance from exploration and mining activities.
Table 2.5.1. This table seems to misrepresent several environmental consequences. We provide the following modificaions for inclusion in the final EISS: Groundwater: Unless a treatment system is installed, the potential for groundwater contamination with nitrates seems fairly high. Therefore, we suggest changing the impact category under Quality to -M. Surface Water: The alternative backfill method could cause major changes to the spring and wetland hydrology. Therefore, we suggest changing the impact category under Quantity to -M. Noise: While heavy equipment operations may not affect nearby residents and recreational users, it would definitely affect wildlife which would otherwise be present in the area. We suggest changing the impact category to -M. Air Quality: Dust will be produced at the mine site and on dirt roads. Therefore, we suggest changing the impact category to -L. Socioeconomics: Regarding employment, it does not seem reasonable to conclude that all facilities would shut down if the Lamefoot Mine is not developed, as Echo Bay also has another mine under exploration in the vicinity. Vegetation: The alternative backfill method would reduce the acreage of wetlands. Therefore, we recommend changing the impact category for Emergent Wetlands and Forested/Shrub-Scrub Wetland to -M. While eliminating grazing was of great benefit to the wetlands, changes in grazing practices are not under consideration in this EISS. Assuming that the many-headed sedge is the special status species referred to, the +M impact category for the Special Status Species should be changed to 0. Also, the impact category "NI" as used several times in the columns for the two Alternatives should be more appropriately listed as "NC". The changes suggested above are probably appropriate for inclusion in a revised Table S-1. **23-16**	23-16 In Tables ES-1 and 2-9, we concur that the No Impact category (NI) was inappropriately used several times. It has been changed to more accurately reflect the impacts relation to the proposed action. We believe the summary of impacts as displayed for groundwater, surface water, noise, air quality, socioeconomics and vegetation are accurately displayed. The comment that grazing practices are not under consideration in this EISS is not consistent with the earlier comment on mitigation that requests continued exclusion of livestock from formerly grazed wetland areas. In fact, elimination of grazing of the wetland area with its many-headed sedge population is a direct and beneficial result of mining activity at this site. During the initial exploration phase, this area was still grazed and the sedge population was severely affected by grazing, as was much of the remainder of this wetland complex. As a company initiated mitigation measure, grazing was removed from this site. This action has resulted in an impressive and immediate response on the part of the vegetation in this wetland complex. This improvement is likely to continue over time. However, it must be recognized that under the no action alternative, grazing may return to this wetland area once the mine is inactivated, and the sedge population will again be adversely affected. Therefore, under the no action alternative, the impact was changed to "-H" to more accurately reflect that situation.
Page 3-7. Last Paragraph. The cyanide concentrations, which are in parentheses, need to include units of measure. **23-17**	23-17 Text has been amended.
Page 4-3. Paragraph 5 This document should provide criteria which would be used to indicate that the spring and wetlands are being dewatered and to trigger mitigation actions that would maintain flow. Use of infiltration pond water to augment wetland flow would be contingent on water quality in the infiltration pond. **23-18**	23-18 A criteria to indicate spring and wetland dewatering and to trigger mitigation have not been developed because it would be difficult to differentiate mine impacts from natural hydrologic variations. For this reason a monitoring program has been developed to monitor wells, springs, and wetlands both upgradient and downgradient from the mine. Comparison of these data can be used to evaluate mine impacts and to indicate if mitigation is necessary and effective. The Hydrologic Monitoring Plan is described in Section 2.3.5 of the FEISS.

Comment			Agency Response
Page 4-7. Paragraph 2 Does the spill response plan include consideration of a catastrophic release from the tailings pond? Does the plan include off-site spills, such as highway accidents involving trucks carrying cyanide? Are truck drivers trained for appropriate response in the case of a highway accident involving a highly toxic substance?	**23-19**	23-19	The Spill Prevention, Control and Countermeasure Plan addresses spills or leaks that may occur on site, spills of materials in transit, and truck driver training. It does not include considerations for catastrophic releases from the tailings pond. The tailings pond has been designed to guard against such catastrophes. The designs and any subsequent modifications are reviewed according to Washington State dam safety criteria by the Washington State Department of Ecology.
Page 4-11. Last Bullet Statement What evidence was examined to determine that waste rock is not generating water quality problems?	**23-20**	23-20	See Section 2.3.7 of the FEISS.
Page 4-44. Section 4.16.1. Item 1 The parameters which are included in "water quality" monitoring of springs needs to be clarified. Spring water should be analyzed for all components in well water not just the four (copper, zinc, lead, and mercury) which are currently required by the National Pollutant Discharge Elimination System under section 402 of the Clean Water Act of 1977. Analytical detection limits must be at or below Washington Water Quality Standards - freshwater chronic concentrations (WAC 173-201A-040). This data would allow a determination of whether or not mining activities are impacting springs and wetlands and biota associated with these areas. Also, whether or not any of the wells described in item 1 are upgradient of proposed mining activities needs to be clarified. We advise that wells should be established upgradient to allow comparisons between groundwater influenced and not influenced by mining activities.	**23-21**	23-21	A Hydrologic Monitoring Plan is described in Section 2.3.5 of the FEISS. The plan includes downgradient and upgradient monitoring locations, sample analysis methods, monitoring frequency, and reporting requirements.
Section 4.16.1. Item 3 The length of time which post closure monitoring woul continue should be stated in the final documents.	**23-22**	23-22	See revised Section 2.3.5.3 Record Keeping and Reporting of the FEISS.
Section 4.16.14. Item 1 This section suggests reconfiguring waste rock/backfill storage areas to provide talus or rock outcrop habitat. It is not clear whether this reconfiguration would occur during or after site operations. We do not advise creating habitat to attract wildlife into an active mining operation.	**23-23**	23-23	Most waste rock will be hauled underground for use as backfill during operations. Surface stockpiles are temporary. Any waste rock remaining on the surface will be covered with soil and revegetated at closure. During operations, the backfill quarry highwalls would be constructed in their final configuration before blasting the next lower bench. This final configuration may include some wildlife habitat which is expected to receive minimal wildlife use during active operations. Therefore, impacts to wildlife are expected to be minimal.
Page C-1. Section 1.1 Both interim and concurrent reclamation procedures should be implemented. These measures would reduce noxious weed infestation and associated herbicide use, maintain soil health, increase the probability of success of post-closure reclamation activities, and allow Echo Bay to modify ineffective reclamation procedures.	**23-24**	23-24	We concur. See Section 1.1, Appendix E.
Pages C-2 and C-6 Information should be provided on why different species would be used for revegetation on public and private lands.	**23-25**	23-25	BLM policy is to use only native species on public lands, hence the different seed mixes for public and private lands.
Page C-3. Section 2.2 Special care should be taken after fertilization to prevent runoff of fertilizer into springs and wetlands during a storm event.	**23-26**	23-26	See erosion and sediment control (Section 2.4 of Appendix E) in the EISS.
Page C-11. Section 6.3 In general, the revegetation monitoring plan should provide more information on techniques and procedures to be used in monitoring. The plan should identify standards against which the success of revegetating would be measured and provide a contingency plan which would be implemented if the initial planting efforts fail. Although the section defines criteria for a satisfactory vegetative community, criteria are needed to define "unsuccessful" seeding attempts which would trigger reseeding. The revegetation monitoring plan should state specifically what efforts would be required of Echo Bay for revegetation. For example, would each revegetation unit be monitored for three years or would the entire site be monitored for three years following closure? The monitoring period should be extended to 10 years, and the document should state what would occur if areas are not successfully revegetated at the end of the monitoring period. The definition of "species diversity" and methods for determining this data, whether or not this goal is met, need to be stated specifically. This section states that visual inspection would be used to determine "species diversity". While this method may be appropriate for determining percent cover, it is likely that measures of "species diversity" would necessitate some type of plot or transect method.	**23-27**	23-27	Site monitoring will be conducted using established BLM standards and guidelines. While the specific methods for monitoring cover and species diversity have not yet been determined, it is likely a modified photo plot and line intercept transect system would be used. If desired standards are not achieved, then appropriate rehabilitation measures would be taken.
Page C-12. Section 8.0 If herbicides would be used to control noxious weeds, manual spot application should be used rather than application to broad areas. This method would protect broad-leaf forbs and shrubs which are not only important components of the habitat, but would allow attainment of criteria for successful revegetation, as stated on page C-11 in section 6.3.	**23-28**	23-28	Manual spot applications of the appropriate herbicide will be used to control limited outbreaks of noxious weeds to minimize loss of desirable forbs and shrubs.

7.0
LIST OF PREPARERS

7.0
LIST OF PREPARERS

The Lamefoot Environmental Impact Statement Supplement was written and produced by Woodward-Clyde under the technical direction of the U.S. Bureau of Land Management, Spokane District Office (Washington). BLM and Woodward-Clyde personnel involved in the production of the EISS, their qualifications, and responsibilities are presented below.

U.S. Bureau of Land Management

George Brown
Project Manager

Qualifications-	B.S. Science, Pennsylvania State University US Bureau of Reclamation, 1 year BLM, 14 years
Responsibilities-	Coordination of EISS effort, schedule control, technical review of documents

Gary Yeager
Asst. Project Manager

Qualifications-	B.S. Agronomy, Pennsylvania State University BLM, 17 years
Responsibilities-	Visual Resources, Socioeconomics, Transportation, Land Use

Judy Thompson
Archaeologist

Qualifications-	M.A. Anthropology, University of Nevada, Reno B.S. Anthropology, Portland State University BLM, 5 years
Responsibilities:	Archaeology and Historical Resources

Todd Thompson
Wildlife Biologist

Qualifications-	B.S. Wildlife Resources, University of Idaho BLM, 6 years
Responsibilities-	Wildlife and Fisheries Habitat

Kelly Courtwright
Mining Engineer

Qualifications-	M.S. Mining Engineering, University of Idaho B.S. Geology, University of Idaho 10 years private industry 9 years BLM
Responsibilities-	Underground Mine Subsidence/Stability, Gold Mining Operations and Processes

Bob Troiano
Natural Resource Specialist

Qualifications-	B.S. Forest Management/Forest Engineering, North Idaho College; 5 years U.S. Forest Service; 6 years Soil Conservation Service; 6 years BLM
Responsibilities-	Soil, Surface Water Quality, Ground Water Quality, Noise/Air Quality, Noxious Weed Control

Pamela Camp
Botanist

Qualifications-	M.S. Botany, University of Nebraska B.S. Biology and Range Management, Utah State University Research Technician, Utah State University, 3 years BLM, 14 years
Responsibilities-	Botany (Sensitive species)

Richard McComas
Natural Resource Specialist

Qualifications-	B.S. Forestry, Utah State University U.S. Forest Service, 1 year BLM, 17 years
Responsibilities-	Vegetation

Ralph Cornwall
Forester

Qualifications-	B.S. Forest Management, Washington State University; 27 years BLM in Coeur d'Alene and Spokane
Responsibilities-	Forest Resource Management

Jake Jakabosky
Environmental Specialist

Qualifications - B.S. Range Management, Wildlife Science, Oregon State University; 8 years Weyerhauser Co.; 15 years BLM

Responsibilities - Gold Mining Operations and Processes, Federal, State and Local Regulations

Paul Summers
Senior Hydrogeologist

Qualifications - B.S. Geology, Utah State University
Post Graduate Training, Water Resource Engineering, Utah State University
25 years, BLM

Responsibilities - Hydrogeologic Investigations, Mining Hydrology, Geochemistry

Eric Hoffman
Geologist

Qualifications - B.S. Geology, Washington State University
U.S. Bureau of Mines, 8 years
U.S. Geological Survey, 8 years
BLM, 11 years

Responsibilities - Subsidence, Gold Mining Operations Processes

Tom Olsen
Geological Engineer

Qualifications - Ph.D., Geological Engineering, SWU Louisiana
M.S., Geology, U. Pennsylvania
B.S., Geology, U. Wisconsin
4 years private industry; 11 years federal government

Responsibilities - Geochemistry

Woodward-Clyde

Scott Mernitz
Project Manager

Qualifications - Ph.D. Land Resources (Environmental Dispute Resolution)
17 years environmental baseline/impacts project management

Responsibilities - Direction and management of EISS effort, budget and schedule control, socioeconomics

Christine Paulsen
Biologist

Qualifications - B.S. Forestry Management
2 years in natural resource management

Responsibilities - Project coordinator, document compilation

Richard Bell
Assistant Project Manager/Soils Scientist

Qualifications - M.S. Soil Science
16 years NEPA project management, and soils/reclamation

Responsibilities - Assistance in coordination of total EISS effort, soils and reclamation

Robert D. Scott
Project Director

Qualifications - M.L.A. Landscape Architecture and Environmental Planning
17 years in resource management, landscape architecture, recreation land use, and project management

Responsibilities - Project oversight and strategy direction, provision of adequate consultant resources for the effort

Nancy VanDyke
Peer Reviewer

Qualifications - M.S. Environmental Sciences
18 years in environmental planning, site assessment, regulatory affairs, and project management

Responsibilities - Technical review of documents

Robert Moran
Hydrogeologist/Geochemist

Qualifications - Ph.D. Geological Sciences
21 years in hydrogeology and geochemistry

Responsibilities - Geochemistry

Mark Zuber
Hydrogeologist and Engineering Geologist

Qualifications - M.S. Earth Resources/Geohydrology
13 years in hydrogeology

Responsibilities - Groundwater, surface water

James Johnson
Project Engineer

Qualifications -	M.S. Civil Engineering (Geotechnical) 14 years in geotechnical engineering
Responsibilities -	Refine and summarize proposed action and alternatives

John Abel, Jr.
Mining Engineer

Qualifications -	D. Sc. Mining Engineering 44 years as a professor, consultant, engineering geologist, mining engineer, and miner
Responsibilities -	Geotechnical/subsidence

David Jones
Visual Resource/Recreation/Land Use Specialist

Qualifications -	B.S. General Agriculture, Landscape Horticulture 10 years in land use management
Responsibilities -	Visual resources, recreation, transportation/land use

Lynn Sharp
Biologist

Qualifications -	M.S. Zoology 22 years in wildlife biology, wetland and terrestrial ecology, and environmental management
Responsibilities -	Wildlife/vegetation

William Killam
Cultural Resources Compliance Coordinator

Qualifications -	B.A. Anthropology/Sociology and Psychology 17 years in cultural resources management
Responsibilities -	Cultural resources

Chris Williams
Water Resources Engineer

Qualifications -	M.S., Earth Resources B.S., Geology 5 years in water resources and surface water hydrology
Responsibilities -	Project description, alternatives, surface water diversion, and POO revisions.

Christopher Freeman
Environmental Planner

Qualifications - B.S. Environmental Policy Analysis and Planning
5 years in policy analysis and planning

Responsibilities - Socioeconomics

Mickey Myers
Air Quality Specialist

Qualifications - B.S. Atmospheric Sciences
15 years in air quality meteorology

Responsibilities - Noise/air quality

John Andrew
Water Resources Engineer

Qualifications - Ph.D. Water Resource Economics
26 years in water resource engineering and management

Responsibilities - Surface water

William O'Reilly
Technical Editor

Qualifications - M.A. English Literature
12 years in technical editing and document production, technical writing instructor

Responsibilities - Document editor

8.0
REFERENCES

8.0
REFERENCES

American Concrete Institute. 1992. ACI 318-89. Revised. 347 pp.

Babcock, C.O., and V.E. Hooker. 1977. Results of Research to Develop Guidelines for Mining Near Surface and Underground Bodies of Water. U.S. Bureau of Mines Info Circ 8471. 17 pp.

Bailey, Rich. 1993. Untitled BLM short report for the Lamefoot Timber Sale.

British Columbia Acid Mine Drainage Task Force (BC Research). 1989. Draft Acid Rock Drainage Technical Guide, Volume 1. Prepared by Steffen Robertson and Kirsten (B.C.), Inc. August.

Cadwallader, Mark, Director of Technical Operations, Gundle Lining Systems, Houston, Texas. 1994. Telephone interview with S. Mernitz, Woodward-Clyde. January 4.

Churchill, T. 1987. "A Cultural Resource Survey of the Overlook Mining Prospect, Cooke Mountain, Washington." Coastal Magnetic Search and Survey Report No. 21.

Churchhill, T. 1988a. "A Cultural Resource Survey of the Key Mining Project, Cook Mountain, Washington." Coastal Magnetic Search & Survey Report No. 30.

Churchhill, T. 1988b. "A Cultural Resource Survey of Additional Lands for the Key Mining Project, Ferry County, Washington." Coastal Magnetic Search & Survey Report No. 31.

Churchhill, T. 1988c. "A Cultural Resource Survey of the Granny Mining Project, Perry County, Washington." Coastal Magnetic Search and Survey Report No. 28.

City of Republic. 1992. City of Republic Economic Development Action Plan and Economic Development Element of Comprehensive Plan.

City of Republic. 1993a. An Open Letter to Washington, D.C. City of Republic.

City of Republic. 1993b. City of Republic Economic Development Action Plan and Economic Development Element of Comprehensive Plan.

Coastech Research. 1989. Investigation of Prediction Techniques for Acid Mine Drainage. November.

Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. 1977. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. 131 pp.

Dayton, S.H. 1988. Hecla's Republic Unit. Eng. & Mining Jour. :34-39. December.

Devlin, Barry. 1994. Chief Geologist, Hecla's Republic Mine. Telephone conversation with C. Paulsen, Woodward-Clyde Consultants. May.

Echo Bay. 1990. Monthly Reports for Kettle River Operations.

Echo Bay. 1993a. Lamefoot Plan of Operations. April 1993 Modification with Supplemental Information, July.

Echo Bay. 1993b. Mining Plan and Backfilling Plan. Handwritten documents provided by Walt Hunt. October 29.

Echo Bay. 1993c. Interviews with Walt Hunt, Echo Bay Minerals, conducted by Woodward-Clyde Consultants. November.

Echo Bay. 1993d. Personal communications from Walt Hunt to Woodward-Clyde. December.

Echo Bay. 1993e. Lamefoot Project Geology, Map 1" = 200 ft. January.

Echo Bay. 1993f. K-2 Project Plan of Operations. Kettle River Operation. Ferry County, Washington. October.

Echo Bay. 1993g. Geologic Cross Section 27,400 North. Provided by Rich Leap of Echo Bay. Fax sent to Mark Zuber, Woodward-Clyde Consultants. November 3, 1993.

Echo Bay. 1993. Figures provided by N. Marshall, Echo Bay. Republic, WA.

Echo Bay. 1994a. Memos from R. Leep to C. Paulsen, Woodward-Clyde Consultants. March and June.

Echo Bay. 1994b. Personal communications from Walt Hunt to Woodward-Clyde. June.

Echo Bay. 1994c. Lamefoot Plan of Operations. Updated through October.

Echo Bay. 1994d. Figures provided by N. Marshall, Echo Bay. Republic, WA.

Echo Bay. Various dates. Monthly Monitoring Reports prepared for Washington Department of Ecology. Available from Echo Bay Minerals, Inc. Republic, WA.

Ennis, John. City Planner of Republic, Washington. 1993. Telephone conversation with C. Freeman, Woodward-Clyde Consultants. November.

Fenneman, N.M. 1931. Physiography of the Western United States. McGraw-Hill. New York.

Ferry Conservation District. 1990. Nonpoint Source Pollution in Trout Creek and Barrett Creek, Ferry County, Washington. Prepared by Kirk Anthony Sullivan for the Ferry Conservation District. August.

Ferry Conservation District. 1991. A Further Evaluation of Nonpoint Source Pollution in the Trout Creek and Barrett Creek Drainage Basins in Ferry County, Washington. Prepared by Steve T.J. Juul and James A. Blake for the Ferry Conservation District. October.

Ferry County. 1991. Final 1991 Budget.

Franklin, J.F. and C.T. Dyeness. 1973 (1988 reprint). Natural Vegetation of Oregon and Washington. Oregon State University Press, Corvallis, Oregon. 452 pp.

Fritts, Lynette 1994. Ferry County Planning Department. Telephone conversation with C. Paulsen, Woodward-Clyde Consultants. May.

Golder Associates, Inc. 1992a. Kettle River Tailings Pond Phase II Expansion Geotechnical Design Summary Report. Prepared for Echo Bay Minerals, Inc. September.

Golder Associates, Inc. 1992b. Plan of Operations, Lamefoot Project, 1992 Drilling. March.

Golder Associates, Inc. 1992c. Environmental Assessment of the Lamefoot Project Proposed Drilling Exploration Program. Prepared for U.S. BLM, Spokane, Washington. June.

Golder Associates, Inc. 1992d. Draft Environmental Impact Statement, Kettle River Key Project Expansion, Ferry County, Washington.

Golder Associates, Inc. 1993. Lamefoot Waste Characterization Report. August.

Golder Associates. 1994. Backfill Quarry Mine Plan, Echo Bay Lamefoot Project. April.

Griffith, G.A., Comprehensive Planning Specialist, State of Washington Department of Community Development Office of Archaeology and Historic Preservation. 1992. Letter to Mr. Craig Holstine, Archaeological and Historical Services, Eastern Washington University regarding the Kettle River Key Mine Expansion Project, dated July 21.

Griffith, G.A., Comprehensive Planning Specialist, State of Washington Department of Community Development Office of Archaeology and Historic Preservation. 1992. Letter to Ms. Ann B. Aldrich, Border Resource Area Manager, Bureau of Land Management regarding Lamefoot Project Drilling Exploration Program. July 2.

Henny, Charles J., Robert J. Hallock, and Elwood F. Hill. 1994. Cyanide and Migratory Birds at Gold Mines in Nevada, USA. Ecotoxicology. 3, 45-58.

Hershfield, David M. 1961. Rainfall Frequency Atlas of the United States for Durations from 30-minutes to 24-hours and Return Periods from 1 to 100 Years, National Weather Service Technical Paper No. 40, 0.5. Department of Commerce, Cooperative Studies Section, Washington, D.C. Reprinted 1963.

Hildebrandt, Romie, Local Landowner, Republic Washington. 1993. Personal Communication with L. Sharp, Woodward-Clyde. November.

Holm, D. 1989. Colorado Department of Health. Personal communication with R. Moran, Woodward-Clyde.

Holstine, Craig. 1991. Identification and Evaluation of Cultural Resources on Federal Lands Identified for Development as Part of the Kettle River Joint Ventures, Key Project Expansion, Ferry County, Washington. Short Report 278, Archaeological and Historical Services, Eastern Washington University.

Holstine, Craig. 1992a. A Cultural Resources Survey on Federal Lands in the Lamefoot Project Area, Ferry County, Washington. Short Report 292, Archaeological and Historical Services, Eastern Washington University.

Holstine, Craig. 1992b. A Cultural Resources Survey on Private Lands in the Lamefoot Project Area, Ferry County, Washington. Short Report 301, Archaeological and Historic Services, Eastern Washington University.

Holstine, Craig. 1993. A Cultural Resources Survey of the Proposed K-2 Mine Project. 1993, Ferry County, Washington. Short Report SR-374, Archaeological and Historical Services. Eastern Washington University.

Holzworth, L. 1972. Mixing Heights Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States. USEPA Office of Air Programs. Research Triangle Park, North Carolina. January.

Hutchinson, I., and R. Ellison (eds.). 1992. Mine Waste Management. California Mining Association.

Hydrometrics, Inc. 1993. Pond Percolation Field Test Report, Lamefoot Operations, Republic, Washington. October 28.

Johnson, Jerry. 1993. Curlew Lake State Park. Park Manager Personal Communication with D. Jones, Woodward-Clyde Consultants. November.

Juul, Steve T.J., and William H. Funk. 1988. A Study of Water Quality of Curlew Lake, Washington. Prepared for The Curlew Lake Sewer District and the Washington State Department of Ecology. WSU Project No. 13A 3998-2595. August.

Juul, Steve T.J., James O. Davis, James A. Blaker, and Thomas A. Salzer. 1993. Nonpoint Pollution at the Headwaters of the San Poil River on Ferry County, Washington. State of Washington Water Research Center. Washington State University, Pullman, WA. p. 99. January.

Kendorski, F.S., I. Khosla, and M.M. Singh. 1979. Criteria for Determining When a Body of Surface Water Constitutes a Hazard to Mining. Department of Commerce NTIS PB81-194938. 364 pp.

Lee. 1991. Taxpayer Information Specialist, Washington State Department of Revenue. Personal communication with A. Schmidt, Planning Information Corporation. June 17, 1991. See Echo Bay 1993a.

Lindeburg, M.R. 1990. Seismic Design of Building Structures. Professional Publications, Inc. Bellmont, California. 128 pp.

Lupfer, Lynn. 1994. School Superintendent, Republic School System. Phone conversation with C. Paulsen, Woodward-Clyde Consultants. May.

Mastrogiuseppe Environmental Consultants. 1991. Botanical Survey for Echo Bay. Exploration, Republic, Washington. 29 pp.

Miller, S.D., J.J. Jeffrey, and J.W.C. Wong. 1991. Use and Misuse of the Acid-base Account for "AMD" Prediction. Randol Gold Forum, Cairns, Australia. pp. 69-75.

Miller, S.H., Senior Geologist, Golder Associates, Inc. 1992. Letter to Adeline Fredin, History/Archaeology Department, Colville Confederated Tribes, regarding Lamefoot Project Cultural Resources Survey. July 1.

Montana Department of State Lands (MDSL), Montana Department of Health and Environmental Sciences, and the U.S. Forest Service. 1992. Final Environmental Impact Statement. Stillwater Mine Expansion 2000 TPD. Application to Amend Plan of Operation and Permit No. 00118. September.

Montgomery, James M. 1985. Water Treatment Principles and Design. John Wiley & Sons, Inc. New York.

Moore, R.C., and M.A. Nawrocki. 1980. Effects of Subsidence from Thick Seam Coal Mining on Hydrology. Department of Commerce NTIS PB80-219280. 242 pp.

Moshiri, Gerald A., Ph.D. (ed.) 1993. Constructed Wetlands for Water Quality Improvement. Lewis Publishers. Boca Raton, Florida.

Mudder, T.T., Ph.D. 1994. Technical Memorandum Re: Review of Nitrate Removal Options for the Lamefoot Mine. Times Limited. January 5. Bozeman, Montana.

National Coal Board (NCB) (British). 1975. Subsidence Engineers' Handbook. NCB Mining Department. 111 pp.

Natural Heritage Data System. 1991. Washington Department of Wildlife - Non-game Program. Letter dated October 14. Mail Stop EX-2, Olympia, WA 98504.

Natural Heritage Data System. 1992. Washington Department of Wildlife - Non-game Program. Information dated March 4. Mail Stop EX-2, Olympia, WA 98504.

NEPA 40 CFR. 1993. Code of Federal Regulations, Protection of Environment 40, Parts 1 to 51. U.S. Government Printing Office. Washington. pp. 45.

Nordstrom, Kirk. U.S. Geological Survey. 1993. Personal communication with S. Jones, Woodward-Clyde. June.

Palmenteer, Alan. 1993. Wildlife Biologist, Washington Department of Wildlife, Fettle Falls, Washington. Telephone conversation with L. Sharp.

Planning Information Corporation. 1991. Ferry County/USBEA Earnings Data and Analysis, Tables 9.1 and 9.2. Prepared for Echo Bay, 1993.

Plumlee, Smith, Ficklin et al. The Environment Geochemistry of Mineral Deposits. Soc. Econ. Geol. Course. In press.

Plumlee, Smith, Ficklin et al. 1993. Empirical Studies of Diverse Mine Drainages in Colorado: Implication for the Prediction of Mine Drainage Geochemistry. U.S. Geological Survey. In press.

Pommen, L.W. 1983. MOE Technical Report 4. The Effect on Water Quality of Explosives Use in Surface Mining. Volume 1: Nitrogen Sources, Water Quality, and Prediction and Management of Impacts. B.C. Ministry of Environment. Victoria, B.C. May.

Ponce, V. Miguel. 1986. Workbook for seminar entitled: Hydrology of Flood Control. Applied Engineering Hydrology. May 28-29. San Diego, CA.

Ray, V. 1933. The Sanpoil and Nespelem, Salishan Peoples of Northeastern Washington. University of Washington Press, Seattle. Reprinted by Human Relations Area Files, New Haven, 1954.

Ray, V. 1936. "Native Villages and Groupings of the Columbia Basin." Pacific Northwest Quarterly, Vol. 27: 99-152, Seattle.

Reed, Porter B. 1988. National List of Plant Species that Occur in Wetlands. National Wetlands Inventory. U.S. Fish and Wildlife Service.

Ryan, Greg. Washington Department of Ecology. 1993. Fax to Mickey Myers regarding emissions inventory, Vaagen Brothers Lumber and Hecla (Knob Hill) Mine. November 12.

Schaefer and Associates. 1992. Tech Notes: Prediction of Acid-Forming Mining Waste, Bozeman, Montana.

Sobek, A.A., W.A. Schuller, J.R. Freeman, and R.M. Smith. 1978. Field and Laboratory Methods Applicable to Overburden and Minesoils. United States Environmental Protection Agency EPA 600/Z-78-054.

State of Washington Department of Ecology (DOE). 1988. Final Environmental Impact Statement, Kettle River Project.

State of Washington Department of Ecology (DOE). 1990. Washington Ground Water Quality Standards. Title 173, Chapter 173-200. Adopted effective November 29.

State of Washington Department of Ecology (DOE). 1993. Report of Examination to Appropriate Public Waters of the State of Washington.

Steffen, Robertson, and Kirsten (B.C.) Inc. (SRK). 1992. Mine Rock Guidelines Design and Control of Drainage Water Quality Report 93301. Prepared for Saskatchewan Environment and Public Safety. Mine Pollution Control Branch. Vancouver, BC. April.

Sweetman, John. 1994. Ferry County Assessor. Phone conversation with C. Paulsen, Woodward-Clyde Consultants. May.

Sweetman, John. Ferry County Assessor. 1993. Telephone conversation with C. Freeman, Woodward-Clyde Consultants. November

Sweetman, John. Ferry County Assessor. 1991. Telephone conversation with A. Schmidt, Planning Information Corporation. June 13. In Echo Bay 1993a.

Thompson, Todd. Biologist, Bureau of Land Management, Spokane, Washington. 1993a. Personal communication with L. Sharp, Woodward-Clyde. September 1.

Thompson, Todd. Biologist, Bureau of Land Management, Spokane, Washington. 1993b. Meeting with L. Sharp, Woodward-Clyde. October 4.

TRC. 1993. Air Quality Permit Document Emissions inventory for the Lamefoot Gold Mining And Processing Facility (Draft). Prepared for Echo Bay Mining Company, Republic, Washington, by TRC Environmental Consultants, Inc., Mountlake Terrace, WA. August 24.

Trico Economic Development District. 1990. Ferry County, Washington Profile.

U.S. Uniform Building Code. 1981. Department of Agriculture (USDA) Soil Conservation Service (SCS) and Forest Service in cooperation with Washington Agricultural Experiment Station. 1979a. Soil Survey of North Ferry Area, Washington. Parts of Ferry and Stevens Counties. September.

U.S. Congress. 1977. The Clean Air Act Amended August 1977, by the 95th Congress, 1st Session. Washington D.C. November.

Uniform Building Code. 1991. Published by International Conference of Building Officials. 1050 pp.

U.S. Department of Agriculture (USDA) Forest Service. 1979b. User Guide to Soils. Mining and Reclamation in the West. General Technical Report. INT-68.

U.S. Bureau of Land Management (BLM). 1986a. Visual Resource Management. Visual Resource Inventory. BLM Manual Handbook 8410-1.

U.S. Bureau of Land Management (BLM). 1986b. Visual Resource Management. Visual Resource Contrast Rating. BLM Manual Handbook 8431-1.

U.S. Bureau of Land Management. 1992. Decision of Approval of Plan of Operations for the Lamefoot Project. Spokane District Office, Spokane, Washington. July 28.

U.S. Department of Commerce, Bureau of the Census. 1991. Population and Housing Report, Ferry County, Washington.

U.S. Fish and Wildlife Service (USFWS). 1987. National Wetland Inventory Map: Republic, Washington 7.5-Minute Quadrangle Map.

U.S. Fish and Wildlife Service (USFWS). Revised 1993. Endangered, Threatened, Proposed and Candidate Species, and Critical Habitat In Washington State, as listed by the U.S. Fish and Wildlife Service. May 17.

U.S. Fish and Wildlife Service (USFWS). 1994. Memorandum to BLM Border Resource Area Manager. re: Lamefoot Mine Informal Consultation. January 19.

U.S. Forest Service (USFS) and Washington Department of Ecology (DOE). 1992. Key Project Expansion Final EIS. Prepared by Golder Associates, Inc. August.

Vickers, T., Taxpayer Service Representative, Washington State Department of Revenue. 1991. Telephone conversation with A. Schmidt, Planning Information Corporation. June 13, 1991. In Echo Bay 1993a.

Voight, B., and W. Pariseau. 1970. "State of the Predictive Art in Subsidence Engineering." Journal Soil Mechanics & Foundation Division. ASCE. Vol. 96, No. 3, SM2. :721-750.

Wainwright, Mitchell. Wildlife Biologist, USFS Republic Ranger District, Republic, Washington. 1993. Telephone Conversation with L. Sharp, Woodward-Clyde. September 1.

Wardell, K. & Partners. 1976. Guidelines for Mining Under Surface Water. Department of Commerce NTIS PB-264 729. 59 pp.

Washington Department of Transportation (WDOT). 1993. Trips System, 1992 Annual Traffic Report.

Washington Department of Wildlife. 1991. Species of Concern List, Non-game Program, Wildlife Management Division. 7 pp.

Washington Department of Wildlife. 1993. Priority Habitat and Species Program. Letter to L. Sharp, Woodward-Clyde. October 11.

Washington Natural Heritage Data System. Washington Department of Wildlife. 1992. Information dated March 4. Mail Stop EX-2. Olympia, WA.

Washington Natural Heritage Program. 1990a. In Mastroguiseppe 1991.

Washington Natural Heritage Program. 1990b. Endangered, Threatened and Sensitive Vascular Plants of Washington. Department of Natural Resources. Olympia, WA. 52pp.

Washington Office of Financial Management. 1991. Forecasting Division. Washington State County Population Projection, 1900-2010. January.

Watson, J.T. and A.J. Danzig. 1993. Pilot-Scale Nitrification Studies Using Vertical Flow and Shallow Horizontal-Flow Constructed Wetland Cells. In: Moshiri 1993.

Woodward-Clyde (W-C). 1994. Groundwater Technical Memorandum. From M. Zuber, W-C to G. Brown, BLM. September 5.

Zender, Steve. Wildlife Biologist, Washington Department of Wildlife, Colville, Washington. 1993. Telephone conversation with L. Sharp, Woodward-Clyde. September 1.

Zipf, Jr., R.K. 1992a. MULSIM/NL theoretical and programmer's manual. USBM Info. Circular 9321. 40 pp.

Zipf, Jr., R.K. 1992b. MULSIM/NL application and practitioner's manual. USBM Info Circular 9322. 45 pp.

APPENDIX A
WATER TREATMENT OPTIONS

APPENDIX A
WATER TREATMENT OPTIONS

Echo Bay has completed a study of possible water treatment needs and options for the proposed Lamefoot Project. The objective of the study was to evaluate water treatment options based on predicted water quality from the underground workings. Currently, as noted in Section 2.3.5.2, Source Control, special emphasis is being placed on nitrate levels, but studies to address and treat other analytes (metals, sulfate, total dissolved solids) have been addressed as well. Options for nitrates and other analytes include:

1. Water treatment plant (three technologies discussed below)
2. Artificial wetlands
3. Land application
4. Pretreatment (in combination with any of 1-3 above, to address the other analytes of concern)

Several initial stages would be to avoid or minimize the need for water treatment.

Below are descriptions of the three nitrate treatment options being considered, followed by a description of the pretreatment option for other analytes.

Water Treatment

The following discussion is taken directly from a study commissioned by Echo Bay through Golder Associates (Mudder 1994). As noted above, nitrate levels are of primary concern, with a treatment goal to reduce nitrate levels from about 25 mg/l to 10 mg/l, at a flow rate of about 75 gpm.

There are two conventional and one emerging nitrate removal technologies which appear most suitable for application at the mine. The two conventional technologies include ion exchange and biological denitrification. The emerging technology involves an electrochemical destruction process in which nitrate is reduced to nitrogen gas and completely removed from solution. Based upon a review of the literature, all three of these technologies can attain the 10 mg/l as N effluent limitation based upon an initial nitrate level of 25 mg/l as N or somewhat higher.

Ion Exchange - The use of ion exchange for removal of nitrate, as well as other cations and anions, is well established on a commercial basis. In practice, the synthetically prepared ion exchange resins are either placed in a fixed bed or suspended in a reactor as a slurry. In either case the untreated mine water is then contacted with the resins to affect treatment. The placement of the ion exchange resins in a fixed bed is the more common configuration, and is similar in design to a filtration system.

The advantages of this technology include:

1. its relative ease of automation

2. the excellent correlation between bench or pilot scale results with full scale performance

3. its reliability with respect to performance and fluctuating flow and nitrate levels

4. the relative short time frame (as compared with other technologies) in which a full-scale system could be designed and placed into operation

The disadvantages include its relatively high capital and operational costs, and the need to backwash the resins, producing a concentrated brine. The brine must then be disposed of in an environmentally acceptable manner. Due to the very high solubility of nitrate, on-site disposal is an ongoing problem because of the mobility of the anion and the possibility that it may reappear in other surface or groundwater. Off-site disposal solves the problem of re-mobilization of the nitrate brine, but at a much higher cost.

The capital and operating costs are influenced to a large extent by the price of the resin itself and the need to replace a portion of resin on an annual basis. The extent of replacement of resin is controlled by the unavoidable loses that occur during backwash, and due to their physical destruction and permanent fouling. Typically, the annual resin replacement will range from 10-20 percent of the entire bed.

One further disadvantage is potential need to both clarify and filter the mine water prior to ion exchange treatment for nitrate removal. In the event the TSS of the mine water routinely exceeds 10 mg/l, incorporation of pressure filtration into the process design could become necessary, adding incrementally to the overall capital and operating costs for ion exchange treatment.

Biological Denitrification - Biological denitrification is a technology or process which utilizes anaerobic bacteria and an organic food source to biochemically reduce nitrate to nitrogen gas, which then volatilizes from solution. The process is truly destructive, and there are no secondary disposal issues other than waste biological sludge. The process is well-established and forms an integral component of many municipal wastewater treatment plants which require stringent control over discharges of nutrients.

Since the process involves living organisms or bacteria, it is more sensitive to toxicants and fluctuations in mine water chemistry than is a physical or chemical treatment technology. The mine water chemistry may require adjustment through pre-treatment to create an environment suitable for biological treatment.

There are three primary disadvantages associated with biological denitrification. The first relates to the need for a supplemental organic carbon source, a requirement best fulfilled by addition of methanol. The need to supply methanol in pure form has a large impact on increasing the overall operating costs for the process. The second disadvantage relates to the extended lead time needed to establish the viability of the process through bench and/or pilot plant scale evaluations. Several months may be required to complete the evaluations necessary to gather the appropriate process design information. The extended time period is controlled by the need to fabricate test equipment, grow and acclimate sufficient biomass, and examine process variability.

The third disadvantage centers on the sensitivity of the process to upsets, which could occur due to the constituents contained in the mine water or frequent changes in its chemistry. Due to the variety of organic compounds (i.e., grouting materials or drilling fluids) and metals contained in the mine water, process upsets could occur, resulting in prolonged periods of poor performance.

Two process designs are envisioned for biological denitrification and treatment of mine water. The first involves a conventional attached growth process system, utilizing either a submerged rotation biological contractor (RBC) or biological filter. Both systems involve conventional off-the-shelf equipment and technology available through a variety of vendors and manufacturers.

The second process design is not conventional and would involve development of an in-situ type system, in which the current disposal method would be used with the addition of methanol and other nutrients as needed. In this case, the soil column itself would serve as the biological reactor, and the nitrate would be removed as the mine water passed downward through the ground. Such an approach has appeal due to its simplicity both in design and cost. However, the approach is novel and unique, and would require extensive laboratory and field testing to demonstrate its viability. There are also concerns relating to the examination of groundwater contamination and permitting of the process.

Electrochemical Destruction - The electrochemical destruction of nitrate is an emerging technology, which has not been installed in large-scale applications. Limited information on the technology exists, and apparently only one vendor has developed and supplies the equipment. The process offers the advantage of complete removal of nitrate through conversion to nitrogen gas. The primary disadvantage relates to the relative high operating costs due to the power consumption.

Consideration of the technology centers on a possible unique application, which would involve its combination with ion exchange. The positive aspects of both technologies are utilized as a result of their combination, and a possibility exists for reducing the overall capital and operating costs for nitrate removal. The application would involve concentrating the nitrate as a brine following removal from the mine water using ion exchange, then subjecting the brine to electrochemical destruction as a concentrated waste. Using this approach would reduce the size and capacity of the equipment needed and the need for disposal of a brine would be eliminated.

This particular technology would require the greatest amount of research and, at a minimum, a short pilot plant or continuous treatment evaluation. Information regarding the availability of pilot plant equipment may be sought during a later study phase. As with ion exchange, there may be a requirement to filter the mine water prior to electrochemical destruction.

Artificial Wetlands

Artificially constructed wetlands simulate natural areas such as marshes, bogs, wet meadows, peat lands, and swamps. Such an area could be constructed specifically for use in water treatment. The construction involves an impervious membrane under the soil substrate. Grasses or other wetland vegetation are then planted and allowed to proliferate. If the wetland is constructed on a gentle slope, waters with undesirable quality are applied to the top of the wetland and allowed to flow slowly to the bottom where they are collected for final disposal with improved quality. The wetland will likely produce intermittent outflows, which would be allowed to infiltrate at the discharge point, or routed elsewhere. Such wetlands have been effective in removing biochemical oxygen demand (BOD) and total suspended solids (TSS) but most systems have been relatively ineffective in removing ammonia nitrogen. The primary limiting factor is believed to be dissolved oxygen (Moshiri 1993).

Nitrate transformation is closely tied to biological activity and other factors (Montgomery 1985; also see Biological Denitrification discussion above). Elevated nitrate levels are not rapidly and effectively attenuated (reduced or weakened) by flow through soil, rock and groundwater (Watson and Danzig 1993). Further, a passive wetland treatment system may eventually become clogged and coated with sediments, thereby reducing its effectiveness if not periodically cleansed and rehabilitated (Holm 1989). Therefore, it is not clear whether such a system on its own would effectively address nitrates and other constituents. Construction, operation, and maintenance costs would likely be low compared to the more active water treatment methods described here, however.

Plants uptake metals and other nutrients from soils or nutrient solutions through their roots and from aerial sources through their foliage. Roots and foliage can also act as barriers to uptake of elements. Total accumulation by plants depends on many factors including (1) the nature of plants, such as species, growth rate, root size and depth, transpiration rate, and nutritional requirements; (2) soil factors such as pH, organic matter content and nature, nutrient status, and amount of metal ions and certain anions like phosphate, sulfate, and sulfides, and clay content and type; (3) environmental and management variables such as temperature, moisture, sunlight, and amendments and fertilization; and (4) the modes of metal toxicity and plant tolerance.

Given these variables, it is difficult to estimate whether or not plants at the site might accumulate site-related metals. Some accumulation of metals may occur within plants, which in turn may be passed up the food chain as animals feed on the plants. However, it is unlikely that the plants themselves would be affected by excessive metals concentrations since in general, plants are much more resistant to an increased concentration than to an insufficient content of a given element. In addition, it is unlikely that animals would be affected, since any birds or mammals that might feed at the wetlands near the site are likely occasional visitors with other primary food sources since the wetlands are relatively small. The high level of human activity at the wetland locations would further preclude frequent wildlife use of the area.

Land Application

Land application which includes infiltration and irrigation allows several processes to occur that can lessen the impact of nitrogen on water. Infiltration of nitrogen-rich water to groundwater provides some dilution; however, it could raise background groundwater levels and tends to attenuate or smooth out peaks in nitrogen concentration. Under aerobic conditions, nitrification will occur, oxidizing more toxic ammonia and nitrite to less toxic nitrate. Under anaerobic conditions, denitrification can occur, releasing nitrogen gas to the atmosphere, and reducing the nitrogen content of the water. A soluble organic carbon energy source is necessary for denitrification to occur. Ammonium will be removed by adsorption on the cation-exchange complex of the soil.

Irrigation will result in the uptake and storage of some nitrogen by plants. Maximum plant uptake is about 100 to 700 kg N ha^{-1} y, depending on the crop, and the crop must be removed to achieve permanent N removal. In addition, the climate, soils and topography of the area must be suitable for the application of the quantity of water necessary to achieve the desired N application (Pommen 1983).

In general, land application would involve direct infiltration into soils, gravels and bedrock to attenuate nitrates and other contaminants, using the cleansing capabilities of the environment. The soils, glacial gravels and other substrates between the mine facility and Curlew Lake could be used for this purpose, for example. Sprinkler/spray assemblies could be constructed to spray contaminated wastewater over suitable substrate. Once again, operation and maintenance costs are comparatively low compared to active treatment. Non-degradation of surface water and groundwater is an issue of concern with the State of Washington and the BLM.

Pretreatment of Mine Water

Pretreatment of mine water may be required to remove sulfates (SO_4), total dissolved solids (TDS), and metals (As, Fe, Mn, etc.) prior to nitrate removal. The purpose of the pretreatment would be to reduce the above constituents to acceptable levels prior to discharge and aid in a more effective removal of nitrates. Each of the various constituents in the water can be removed effectively, but this requires a combination of processes. One potential pretreatment system involves several steps. These are:

- Chemical Addition
- Precipitation
- Clarification
- Green Sand Filtration
- Sludge Thickening
- Dewatering (Filter press)
- Reverse Osmosis
- Evaporation

Chemical addition would involve feeding chemicals such as lime or caustic to increase pH and precipitate particular metals. Oxidation chemicals such as peroxide or potassium permanganate would be added to oxidize and precipitate Fe, Mn, and coprecipitate As. Polymers would be added to enhance suspended solids removal. Precipitation would be followed by filtration. The solids would be collected in a tank and allowed to thicken. The sludge would then be pressed to remove water and produce a cake for on-site or off-site disposal. After filtration, the water would pass through a reverse osmosis unit for further removal of suspended and dissolved solids. Approximately 10% of the flow becomes a concentrated reject stream. This stream would require further treatment by evaporation to produce a solid for on-site or off-site disposal.

The pretreatment system could be added to the front end of each of the nitrate removal alternatives (ion exchange, biological denitrification, electrochemical). Although the potential removal of some nitrates in the pretreatment step would reduce the size, configuration, or cost of the nitrate removal alternatives, a conservative assumption for this evaluation is that nitrates will not be removed in the pretreatment step.

The advantages to this system include flexibility in adjusting treatment if water quality changes. Constituents are also removed prior to the nitrate removal, thus enhancing the effectiveness of that process.

The disadvantages are that the pretreatment system involves multiple unit operations and is equipment-intensive, requiring tanks, pumps, mixers, materials handling equipment, instrumentation and controls, and chemicals. Operation and maintenance of the system would be labor-intensive and complex due to the numerous unit operations.

APPENDIX B
1992-1993 GEOCHEMISTRY REPORT AND MONITOR WELL DATA

APPENDIX B-1
LAMEFOOT GEOCHEMISTRY REPORT, ECHO BAY MINERALS
PREPARED BY GOLDER ASSOCIATES,
AUGUST, 1993

APPENDIX B-1
TABLE OF CONTENTS

Section			Page
1.0	INTRODUCTION		B1-1
	1.1	OBJECTIVES	B1-1
	1.2	TECHNICAL APPROACH	B1-1
	1.3	HYDROGEOLOGIC SETTING	B1-3
2.0	INITIAL GEOCHEMICAL CHARACTERIZATION STUDIES		B1-5
	2.1	PHASE I - GEOLOGIC EVALUATION	B1-6
	2.2	PHASE II - IDENTIFICATION AND CHARACTERIZATION OF WASTE AND MINE WALL ROCK LITHOLOGIES	B1-7
		2.2.1 Identification of Rock Lithologies	B1-7
		2.2.2 Waste Rock Volumes and Subsurface Lithologic DIstribution	B1-7
	2.3	PHASE III - PRELIMINARY ACID BASE ACCOUNTING ANALYSES	B1-8
		2.3.1 Sample Selection	B1-8
		2.3.2 Acid Base Accounting Procedures	B1-8
		2.3.3 Interpretation of ABA Results	B1-9
		2.3.4 Limitations	B1-10
	2.4	RESULTS	B1-11
	2.5	SUMMARY OF PHASE III PRELIMINARY ACID BASE ACCOUNTING	B1-12
		2.5.1 Waste/Mine Wall Rock Samples	B1-12
		2.5.2 Backfill Samples	B1-12
3.0	CONTINUING WASTE CHARACTERIZATION PROGRAM		B1-14
	3.1	PHASE IV - SELECTION OF ADDITIONAL MINE WALL ROCK SAMPLES	B1-14
	3.2	PHASE V - SECONDARY ACID BASE ACCOUNTING ANALYSIS	B1-15
	3.3	PHASE VI - IDENTIFICATION OF GEOCHEMICAL DOMAINS	B1-16
	3.4	PHASE VI CONCLUSIONS	B1-16
	3.5	PHASE VII - LITHOLOGIC AND GEOCHEMICAL CORRELATION WITH KEY EXPANSION	B1-18
		3.5.1 Lithologic Correlation	B1-18
		3.5.2 Geochemical Correlation	B1-20
4.0	ACID DRAINAGE FROM MINE WALLS AND MITIGATIVE APPROACH		B1-23
	4.1	ACID DRAINAGE FROM MINE WALLS	B1-23
	4.2	DEVELOPMENT OF THE MITIGATIVE APPROACH	B1-25

Section Page

4.2.1 Prevention of AMD B1-25
4.2.2 Abatement of Acid Mine Drainage B1-26

5.0 REFERENCES B1-27

Following Page

LIST OF TABLES

TABLE 2-1 SUMMARY OF WASTE/MINE WALL ROCK SAMPLES SUBMITTED FOR PHASE III ACID BASE ACCOUNTING ANALYSIS B1-9
TABLE 2-2 GEOLOGIC LOGS FOR BACKFILL EXPLORATION HOLES B1-9
TABLE 2-3 SELECTED EVALUATION CRITERIA FOR THE LAMEFOOT ACID-BASE ACCOUNTING ANALYSES B1-10
TABLE 2-4 RESULTS OF PHASE III ACID-BASE ACCOUNTING ANALYSIS OF WASTE/MINE WALL ROCK SAMPLES B1-11
TABLE 2-5 RESULTS OF PHASE III ACID BASE ACCOUNTING ANALYSIS OF LAMEFOOT BACKFILL SAMPLES B1-11
TABLE 2-6 ABA RESULTS RELATIVE FOR WASTE/MINE WALL ROCK SAMPLES RELATIVE TO THE EVALUATION CRITERIA B1-13
TABLE 2-7 ABA RESULTS FOR THE BACKFILL SAMPLES RELATIVE TO THE EVALUATION CRITERIA B1-13
TABLE 3-1 SUMMARY OF SAMPLES SUBMITTED FOR PHASE V ACID BASE ACCOUNTING ANALYSES B1-15
TABLE 3-2 ACID BASE ACCOUNTING RESULTS FOR PHASE V TESTING B1-15
TABLE 3-3 SUMMARY OF WASTE ROCK LITHOLOGIES PRESENT AT THE KEY EXPANSION AND LAMEFOOT PROJECTS B1-18
TABLE 3-4 SUMMARY OF FACTORS INFLUENCING POTENTIAL GEOCHEMICAL BEHAVIOR OF THE WASTE/MINE WALL ROCK AT BOTH THE KEY EXPANSION AND LAMEFOOT PROJECTS B1-18

Following Page

LIST OF FIGURES

FIGURE 1-1 FLOW CHART ILLUSTRATING THE WASTE CHARACTERIZATION PROGRAM B1-1
FIGURE 1-2 CONCEPTUAL MODEL FOR HYDROGEOLOGY AT THE LAMEFOOT PROJECT AREA B1-3
FIGURE 1-3 RESULTS OF MARCH 1993 UNDERGROUND HYDROGEOLOGIC SURVEY B1-4
FIGURE 2-1 GEOLOGIC CROSS SECTION ILLUSTRATING THE DISTRIBUTION OF WASTE ROCK LITHOLOGIES B1-7
FIGURE 2-2 GEOLOGIC CROSS SECTION ILLUSTRATING THE DISTRIBUTION OF WASTE ROCK LITHOLOGIES B1-8
FIGURE 2-3 ESTIMATED WASTE ROCK PERCENTAGES B1-8
FIGURE 2-4 DISTRIBUTION OF WASTE ROCK LITHOLOGIES EAST WALL OF HW STOPES B1-8
FIGURE 2-5 DISTRIBUTION OF WASTE ROCK LITHOLOGIES WEST WALL OF MAIN STOPES B1-8
FIGURE 2-6 DISTRIBUTION OF WASTE ROCK LITHOLOGIES WEST WALL OF HW STOPES B1-8
FIGURE 2-7 DISTRIBUTION OF WASTE ROCK LITHOLOGIES EAST WALL OF MAIN STOPES B1-8
FIGURE 2-8 EAST WALL STOPES EXPOSURE SHOWING LITHOLOGY AND EXPLORATION/DEVELOPMENT WORKINGS B1-8
FIGURE 2-9 WASTE AND MINE WALL ROCK GEOCHEMICAL SAMPLING LOCATION MAP B1-9

APPENDIX B-1
LAMEFOOT GEOCHEMISTRY REPORT ECHO BAY MINERALS
AUGUST 1993

1.0 INTRODUCTION

The Lamefoot waste characterization program was developed as an extension of the efforts implemented for Echo Bay's Key Expansion Project. The waste characterization program completed for the Key Project is discussed fully in Appendix E of the Final Environmental Impact Statement, Kettle River Key Project Expansion (Golder 1992). Figure 1-1 illustrates the various procedures which define the waste characterization program for both the Key Expansion and Lamefoot Projects. These programs represent an iterative approach which incorporated sufficient flexibility to allow modifications as data was obtained.

1.1 OBJECTIVES

The principle objectives of the Lamefoot Project waste characterization program are summarized as follows:

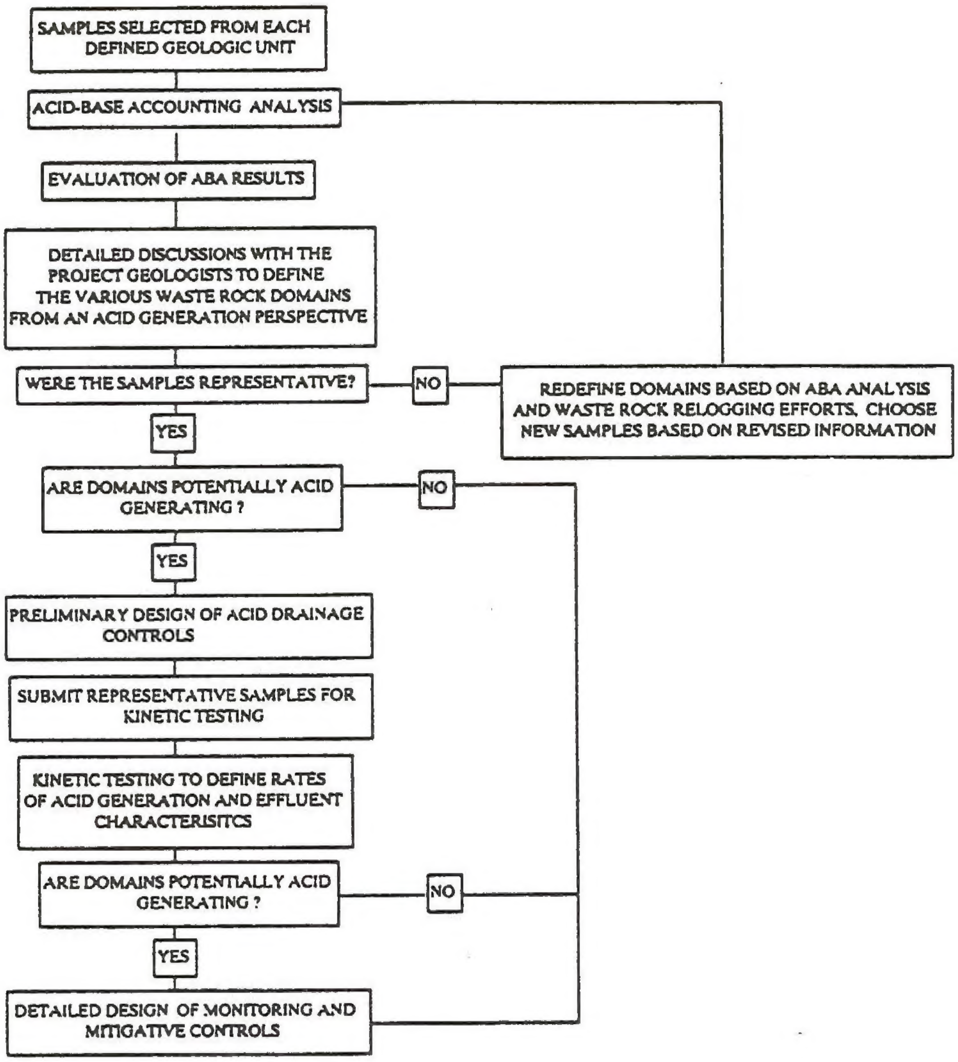
- Predict whether the waste rock generated during mining will potentially produce acid rock drainage (ARD);
- Predict whether the zones of sulfide bearing rock exposed in the underground workings will generate acid mine drainage (AMD);
- Evaluate whether potentially acid generating lithologies and waste rock could introduce contaminants into the environment;
- Optimize the mine closure design; and,
- Optimize the temporary storage and final disposal of the waste removed from the mine.

1.2 TECHNICAL APPROACH

The technical approach developed for the Lamefoot waste characterization program is based on the large geologic and geochemical database which was compiled during waste characterization efforts completed for the Key Expansion Project. The geologic environments of both the Lamefoot and Key Expansion ore deposits are virtually identical therefore, the waste rock domains are also correlative. This geologic similarity allows the full range of geochemical data generated for the Key Expansion to augment the current Lamefoot waste characterization program. One of the initial objectives of the technical approach adopted for the Lamefoot waste rock characterization program involves establishing the degree of variability (both geochemical and geologic) between the Lamefoot and Key Project waste rock domains.

Extensive work was performed as part of the Key Expansion waste characterization program to ensure that the geochemical variability of the various waste rock domains was adequately defined. This process included both acid base accounting and kinetic testing. Preliminary predictions regarding potential acid generation were developed for each of the waste rock domains by evaluating their respective acid base accounts relative to criteria involving the acid neutralizing potential and the acid generation potential (see Appendix E, Golder 1992).

The validity of using acid base accounting (ABA) data to predict the acid generation potential of the various waste rock domains was subsequently confirmed through the kinetic testing completed as part of the Key Expansion waste characterization program. The results of the kinetic testing program illustrated that the


SAMPLES SELECTED FROM EACH DEFINED GEOLOGIC UNIT
ACID-BASE ACCOUNTING ANALYSIS
EVALUATION OF ABA RESULTS
DETAILED DISCUSSIONS WITH THE PROJECT GEOLOGISTS TO DEFINE THE VARIOUS WASTE ROCK DOMAINS FROM AN ACID GENERATION PERSPECTIVE
WERE THE SAMPLES REPRESENTATIVE?
NO
REDEFINE DOMAINS BASED ON ABA ANALYSIS AND WASTE ROCK RELOGGING EFFORTS. CHOOSE NEW SAMPLES BASED ON REVISED INFORMATION
YES
ARE DOMAINS POTENTIALLY ACID GENERATING ?
NO
YES
PRELIMINARY DESIGN OF ACID DRAINAGE CONTROLS
SUBMIT REPRESENTATIVE SAMPLES FOR KINETIC TESTING
KINETIC TESTING TO DEFINE RATES OF ACID GENERATION AND EFFLUENT CHARACTERISITCS
ARE DOMAINS POTENTIALLY ACID GENERATING ?
NO
YES
DETAILED DESIGN OF MONITORING AND MITIGATIVE CONTROLS

Golder Associates Denver, Colorado

TITLE

FLOW CHART ILLUSTRATING THE WASTE CHARACTERIZATION PROGRAM

CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

DRAWN	KAW	DATE	AUG 1993	JOB NO.	933-2614
CHECKED	JC	SCALE		DWG NO./REV. NO.	
REVIEWED	JC	FILE NO.		FIGURE NO.	1-1

criteria established to define acid generation potential, based on ABA data for the various waste rock domains, were representative of actual geochemical behavior and appropriately conservative.

The geologic/lithologic similarity between the two sites, and the usefulness of ABA data to properly predict anticipated geochemical behavior of the various waste rock domains provide the focus for the Lamefoot waste characterization program. Much of the focus of the Lamefoot program is centered on establishing both the geologic/geochemical similarities and variabilities between the waste rock domains present at both sites in order to facilitate utilization of existing data and interpretations to direct the Lamefoot Project geochemical program and waste disposal design.

The technical approach developed for the Lamefoot waste characterization program can be summarized as follows:

- Confirm the lithologic/geologic similarity between the waste rock domains present at both the Lamefoot and Key Expansion projects;
- Establish the geochemical variability, if any, between the waste rock domains common to both the Lamefoot and Key Expansion projects; and,
- Identify the waste rock domain(s) present at the Lamefoot project with the highest potential for acid generation and bias future sampling and geochemical testing to establish the variability in acid generation potential within these domains.

This technical approach has been implemented through a seven phase waste characterization program consisting of the following elements:

- Phase I Geologic Evaluation.
- Phase II Identification and Characterization of Mine and Waste Rock Lithologies.
- Phase III Preliminary Acid Base Accounting Analysis.
- Phase IV Selection of Additional Mine Rock Samples for Secondary Geochemical Characterization.
- Phase V Secondary Acid Base Accounting Analysis.
- Phase VI Definition of Geochemical Mine and Waste Rock Domains.
- Phase VII Correlation with Key Expansion Waste Characterization Program.

The first three phases represent the initial step in an iterative waste characterization program which focused on providing a lithologic and geochemical foundation. Phases IV through VII represent the secondary elements of the program and focus on defining more clearly the potential geochemical variability and behavior of the waste rock domains.

1.3 HYDROGEOLOGIC SETTING

The Lamefoot Project site has two general types of groundwater occurrence. One is the uppermost water table which occurs within the unconsolidated alluvial and glacial deposits at topographic lows and along the flatland at the mountain front. At higher elevations and on mountain side slopes, this uppermost groundwater occurrence is irregular and controlled by the residual soils/bedrock contact within both the soils and the more fractured weathered bedrock surface. The groundwater at higher elevations flows downgradient and is controlled primarily by the topography of the bedrock surface. Most precipitation recharges the shallow alluvial/glacial unit and discharges from the site as near-surface alluvial groundwater. To a lesser extent, a portion of the shallow groundwater percolates into fractures to recharge the underlying unweathered bedrock.

The second type of groundwater at the Lamefoot Project site occurs within the deeper fractured bedrock (e.g., at the depths of the current Lamefoot mine). Bedrock groundwater occurs locally within a small number of water bearing fractures. Although only small amounts of groundwater have been encountered in the bedrock at the site, there is the potential for higher flows where large, interconnected, open fractures occur. No such large fractures have been evidenced or suggested in the workings to date or in close spaced exploration drilling. An exception is the relatively high flow rate (50 gpm) produced from the water supply well at the facilities area that intercepts a zone of highly fractured shale bedrock at a depth of 265 feet below ground surface. The water supply well was located and drilled to encounter the geologic structural control for the Wolfe Camp valley and the range front. This water bearing fracture zone is interpreted to represent a northerly trending structure believed to be unrelated to the mineralized fracture zones. The Lamefoot underground workings to date have not encountered related water bearing fracture zones.

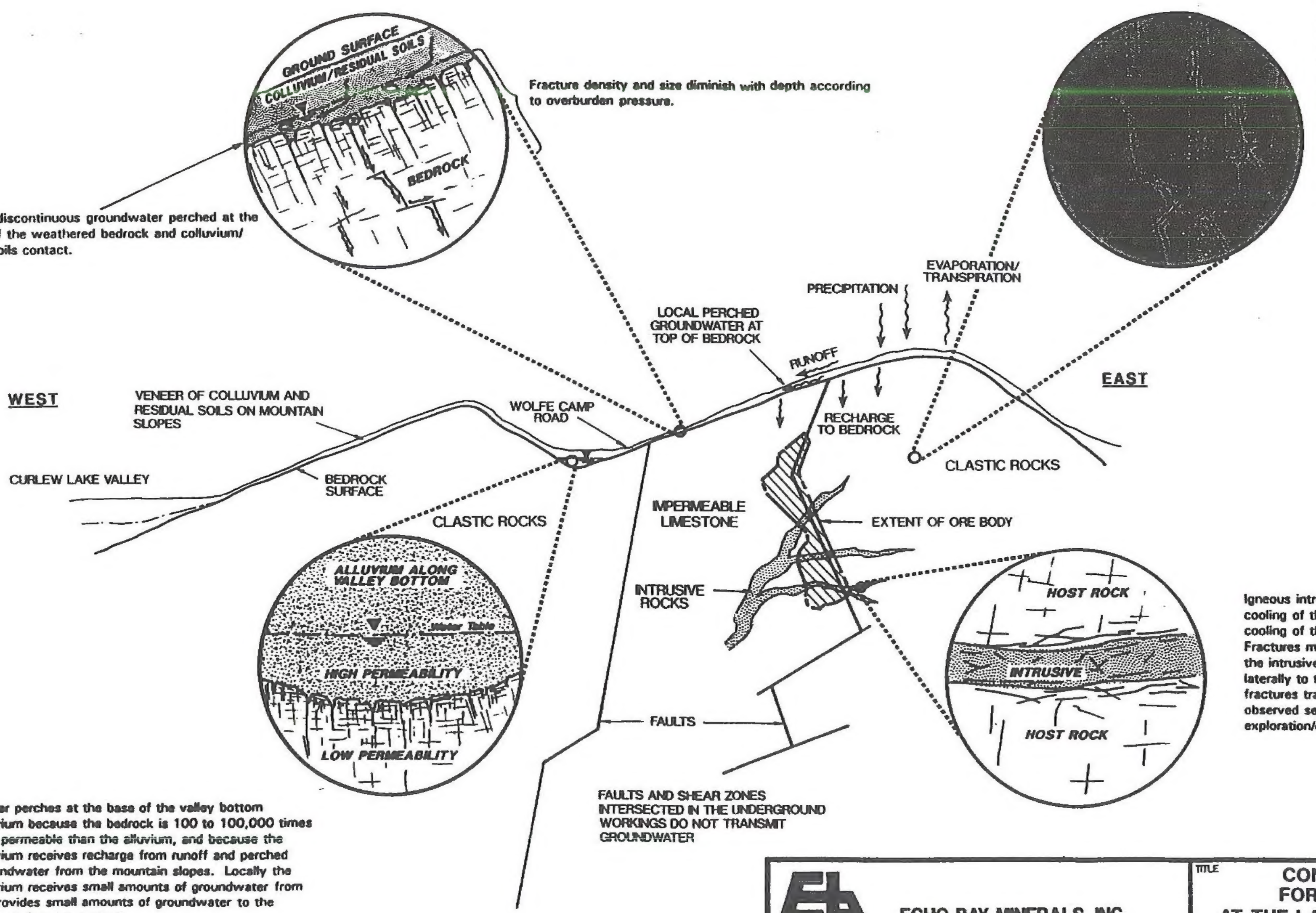
Site experience shows that some drill holes may be dry, while others are wet where water bearing fractures are intercepted. Similarly, in the underground exploration and development workings, isolated portions of the mine walls are wet or dripping while the majority of the walls are dry. Figure 1-2 presents a conceptual diagram of principal components of the hydrogeology of the Lamefoot Project site.

Bedrock geology controls the occurrence of groundwater within the Lamefoot mine. Because fractures are the sole mechanism for flow, bedrock fracturing as related to rock type, mineralization, structure (faults), and truncation by intrusives strongly determines the location and magnitude of groundwater flow.

As observed during both the surface drilling and underground exploration programs, bedrock comprised of unaltered limestone generally yields no water. Even where fractured, the unaltered limestone contains little or no water, suggesting that fractures in this unit are not sufficiently extensive and/or interconnected to carry groundwater. In contrast, the massively mineralized limestone (i.e., low grade ore) which is well fractured and jointed carries small quantities of groundwater. Fractures associated with the rhyodacite intrusive rocks tend to yield the more significant flows observed underground and during surface drilling. These intrusive-related water bearing fractures have been noted in both the rhyodacite itself and in the host rock immediately surrounding the intrusion. Though the intrusion related fractures produce the most significant water encountered in the bedrock, quantities are nonetheless small. Of the several visibly flowing intrusive-related fractures observed underground, all produced water at less than 0.08 gpm from a single fracture or fracture set.

The elevation of the phreatic surface within the bedrock varies according to the degree of interconnectedness, orientation, and spacing of the fractures that makeup the fracture system. The degree of connection a particular fracture or fracture set has with the surface is also an important factor which controls the phreatic surface. Because of variability in fracture characteristics the phreatic surface can vary dramatically between the localized fracture sets (see Figure 1-1).

The fact that no springs occur on the mountain slopes and that only small quantities of inflow are observed in the mine suggest small amounts of recharge to the bedrock. At no time during the exploration mining program has groundwater discharged into the workings at high flow rates or pressures (i.e., pressurized inflow on a face immediately following blasting).



Fracture density and size diminish with depth according to overburden pressure.

Thin and discontinuous groundwater perched at the contact of the weathered bedrock and colluvium/residual soils contact.

The elevation of the phreatic surface in the bedrock is highly dependent on the spacing, orientation, size, and interconnectedness of the fracture network. Therefore, the phreatic surface varies from location to location. The degree of connection of the fracture network to the surface for recharge by precipitation is a critical factor.

FAULTS AND SHEAR ZONES INTERSECTED IN THE UNDERGROUND WORKINGS DO NOT TRANSMIT GROUNDWATER

Igneous intrusive rock fractures are created from the cooling of the intrusion and from the heating and cooling of the immediately surrounding host rock. Fractures may be extensive and interconnected along the intrusive/host rock contact, but are confined laterally to the immediate area of the intrusive. These fractures transmit the majority of groundwater observed seeping into the underground exploration/development workings.

Water perches at the base of the valley bottom alluvium because the bedrock is 100 to 100,000 times less permeable than the alluvium, and because the alluvium receives recharge from runoff and perched groundwater from the mountain slopes. Locally the alluvium receives small amounts of groundwater from or provides small amounts of groundwater to the bedrock fracture system.

ECHO BAY MINERALS, INC.	TITLE CONCEPTUAL MODEL FOR HYDROGEOLOGY AT THE LAMEFOOT PROJECT AREA		
CLIENT/PROJECT ECHO BAY MINERALS, INC. LAMEFOOT PROJECT	DRAWN LC	DATE JUNE 1993	JOB NO. 933-2614
	CHECKED	SCALE NOT TO SCALE	DWG. NO./REV. NO.
	REVIEWED	FILE NO.	FIGURE NO. 1-2

Inflow to Existing Workings

Groundwater inflow rates to the underground exploration/development workings are currently being monitored on a monthly basis. In addition, an evaluation of the inflow as it relates to rock lithologies and structure was performed during the week of March 15, 1993. At that time, wet areas, drips, and flowing water were mapped, flow rates estimated, samples collected for laboratory analysis, and field tests performed for pH, electrical conductance and temperature. Figure 1-3 presents the results of that evaluation. Water inflow rates were estimated and field water quality tests were taken from four observed sources of groundwater inflow:

- Inflow from all 10 exploration boreholes drilled from the surface which were intersected by the workings;
- Occasional inflow from horizontal exploration boreholes drilled into the drift walls and vertical boreholes drilled into the drift roof into which were installed rock bolts for securing roof straps;
- Rare to occasional inflow from fractures associated with dikes and sills cutting the rock fabric; and,
- Occasional to common inflow from highly altered and mineralized ore-bearing fractured/jointed micritic limestone.

Mine inflow was limited to discrete or more highly fractured areas, the largest of which occurred over an area estimated at 100 square feet. Areas of unaltered limestone were commonly less fractured, and produced little water. This suggests that the fractures in the unaltered limestone are not extensively interconnected and are not subject to surficial recharge. At the time of the underground evaluation, no extensive areas of clastic rock were exposed. On those limited clastic exposures no wet areas were observed. A discussion of the waters encountered by the type of source is presented below.

Intersected Boreholes

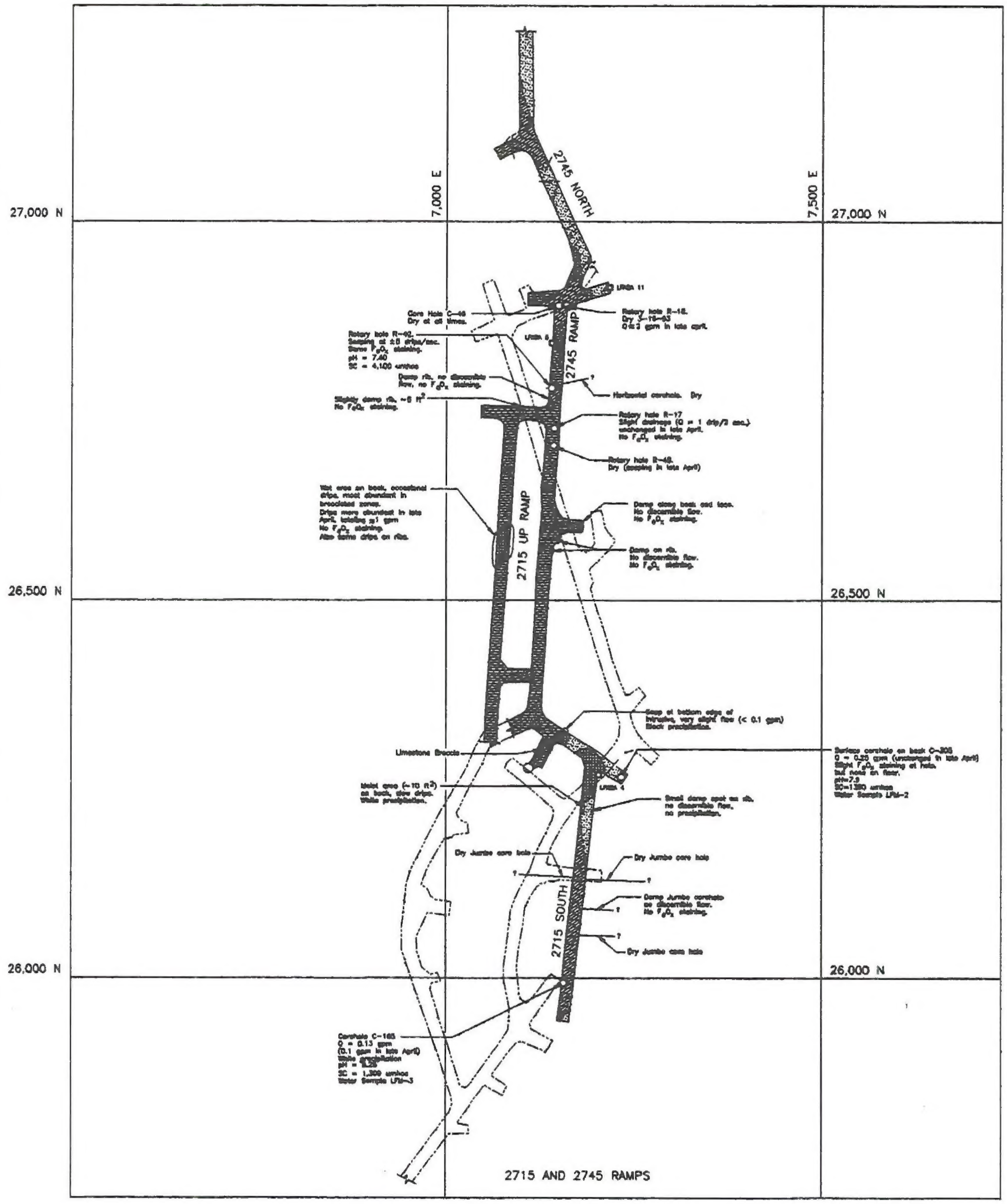
The largest inflows observed in the workings were noted where surface-drilled boreholes were intersected by the workings. Of the 10 boreholes encountered five had measurable discharge, four were dry, and one had a discharge rate too low to measure. Maximum flow from a single borehole was estimated at 2 gpm, and total inflow from the five flowing boreholes was an estimated 2.38 gpm during the March 1993 evaluation. This represents the highest inflow observed in the workings. Because the boreholes are currently open to a depth near the surface, the exact source of water cannot be identified with confidence. The source could be from direct precipitation/snow melt inflowing from the surface, discharge of shallow perched saturation in the residual soils and weathered upper bedrock, or from deeper fractures.

Horizontal Boreholes Into Drift Walls

Horizontal exploration boreholes drilled into the mine walls were generally dry during the March 1993 underground evaluation. Where wet, seepage rates were very low with little or no visible flow.

Rockbolt Boreholes

The vast majority of rockbolt boreholes were dry at the time of the underground evaluation. Those that showed evidence of moisture were generally located in or adjacent to the intrusive rocks.



LEGEND:

▨ CLASTICS (UNDIFFERNTIATED)

■ LIMESTONE

■ INTRUSIVES

■ ALTERED LIMESTONE

■ LIMESTONE BRECCIA

—— ' HORIZONTAL COREHOLE INTO RIB. '?' INDICATES UNKNOWN DEPTH

▫ ACID BASE ACCOUNTING SAMPLE LOCATION

◇ SURFACE BOREHOLE INTERCEPT

⁄ ⁄ FAULTS/MAJOR JOINTS

⁄ INTRUSIVE DIKE

NOTES:

1. SHOWN IS THE EXTENT OF GEOLOGIC MAPING AS OF MARCH 1993 EXCEPT WERE NOTED. THE UNDERGROUND WATER INFLOW CONDITIONS OBSERVED MARCH 16, 1993.
2. WATER QUALITY MEASURED USING FIELD pH AND SPECIFIC CONDUCTANCE METER.
3. ACID BASE ACCOUNTING (ABA) SAMPLES LFABA-7, LFABA-8, LFABA-9 AND LFABA-10 ARE LOCATED IN WORKINGS DRIVEN AFTER MARCH 1993 AND ARE NOT SHOWN.
4. WATER SAMPLES LFM-4 WAS COLLECTED IN THE ACCESS TUNNEL. LFM-5 WAS COLLECTED IN THE MINE SUMP WATER NEAR THE PORTAL.

Eb

ECHO BAY LAMEFOOT PROJECT

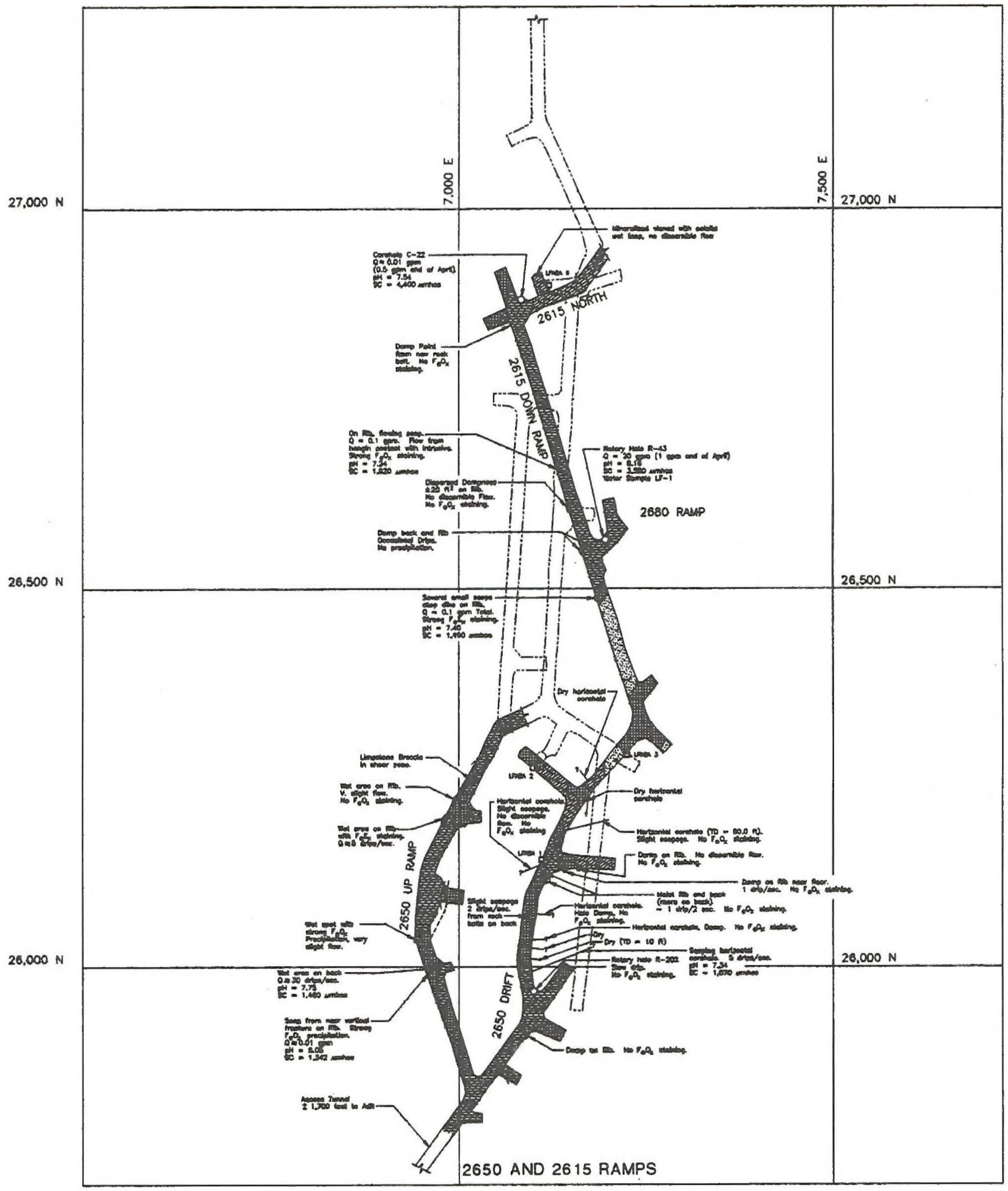
Source: Adapted from Echo Bay 1993a

Echo Bay Minerals Co.
Lamefoot Mine
Kettle River Operations
Republic, Washington

RESULTS OF MARCH 1993 UNDERGROUND HYDROGEOLOGIC SURVEY

DATE JUNE 1993	SCALE	FIG. NO. 1-3A

SH1


7,000 E
7,500 E
27,000 N
27,000 N
26,500 N
26,500 N
26,000 N
26,000 N
Mineralized vaned with calcite wet loop, no discernible flow
Corehole C-22
Q ≈ 0.01 gpm
(0.5 gpm end of April)
pH = 7.54
SC = 4,400 umhos
LFABA 6
2615 NORTH
Damp Point from new rock bolt. No FeOx staining.
2615 DOWN RAMP
On Rib, flowing seep. Q = 0.1 gpm. Flow from hangin contact with intrusive. Strong FeOx staining. pH = 7.34 SC = 1,820 umhos
Rotary Hole R-43
Q = 20 gpm (1 gpm end of April)
pH = 8.16
SC = 3,580 umhos
Water Sample LF-1
Dispersed Dampness ±20 ft² on Rib. No discernible Flow. No FeOx staining.
2680 RAMP
Damp back and Rib Occasional Drips. No precipitation.
Several small seeps along dike on Rib. Q = 0.1 gpm Total. Strong FeOx staining. pH = 7.40 SC = 1,990 umhos
Dry horizontal corehole
Limestone Breccia in shear zone.
LFABA 2
LFABA 3
Wet area on Rib. V. slight flow. No FeOx staining.
Dry horizontal corehole
Horizontal corehole Slight seepage. No discernible flow. No FeOx staining
Wet area on Rib with FeOx staining. Q ≈ 8 drips/sec.
Horizontal corehole (TD = 80.0 ft). Slight seepage. No FeOx staining.
LFABA 1
Damp on Rib. No discernible flow. No FeOx staining.
Damp on Rib near floor. 1 drip/sec. No FeOx staining.
2650 UP RAMP
Moist Rib and back (more on back) ~ 1 drip/2 sec. No FeOx staining.
Slight seepage 2 drips/sec. from rock bolts on back
Horizontal corehole. Hole Damp. No FeOx staining.
Horizontal corehole, Damp. No FeOx staining.
Wet spot with strong FeOx Precipitation, very slight flow.
Dry
Dry (TD = 10 ft)
Seeping horizontal corehole. 5 drips/sec. pH = 7.34 EC = 1,070 umhos
Rotary hole R-202 Slow drip. No FeOx staining.
Wet area on back Q ≈ 30 drips/sec. pH = 7.75 SC = 1,460 umhos
2650 DRIFT
Seep from near vertical fracture on Rib. Strong FeOx precipitation. Q ≈ 0.01 gpm pH = 8.05 SC = 1,342 umhos
Damp on Rib. No FeOx staining.
Access Tunnel ≥ 1,700 feet to Adit
2650 AND 2615 RAMPS

LEGEND:

- ▨ CLASTICS (UNDIFFERNTIATED)
- ■ LIMESTONE
- ■ INTRUSIVES
- ■ ALTERED LIMESTONE
- ■ LIMESTONE BRECCIA
- —• HORIZONTAL COREHOLE INTO RIB. "?" INDICATES UNKNOWN DEPTH
- ▫ ACID BASE ACCOUNTING SAMPLE LOCATION
- ◇ SURFACE BOREHOLE INTERCEPT
- ⁄ FAULTS/MAJOR JOINTS
- ⁄ INTRUSIVE DIKE

NOTES:

1. SHOWN IS THE EXTENT OF GEOLOGIC MAPING AS OF MARCH 1993 EXCEPT WERE NOTED. THE UNDERGROUND WATER INFLOW CONDITIONS OBSERVED MARCH 16, 1993.
2. WATER QUALITY MEASURED USING FIELD pH AND SPECIFIC CONDUCTANCE METER.
3. ACID BASE ACCOUNTING (ABA) SAMPLES LFABA-7, LFABA-8, LFABA-9 AND LFABA-10 ARE LOCATED IN WORKINGS DRIVEN AFTER MARCH 1993 AND ARE NOT SHOWN.
4. WATER SAMPLES LFM-4 WAS COLLECTED IN THE ACCESS TUNNEL. LFM-5 WAS COLLECTED IN THE MINE SUMP WATER NEAR THE PORTAL.

ECHO BAY LAMEFOOT PROJECT

Source: Adapted from Echo Bay 1993a

Echo Bay Minerals Co.
Lamefoot Mine
Kettle River Operations
Republic, Washington

RESULTS OF MARCH 1993 UNDERGROUND HYDROGEOLOGIC SURVEY

DATE	SCALE	FIG. NO.
JUNE 1993		1-3B

SH2

Low Grade Ore (Mineralized Limestone)

Wet conditions observed in the low grade ore zones were generally associated with dispersed, larger areas (25 to 100 square feet) of moisture which occurred on walls or roofs. However, no concentrated flow (drips, rivulets, etc.) was observed to occur within these areas. The more fractured, jointed and broken-up nature of the mineralized areas in the limestone may be the cause of the dispersed low inflow rates.

Outflow from Existing Workings

At the time of the underground evaluation the total inflow to the mine was estimated to be on the order of 25 to 35 gpm. This estimate includes all sources including the surface exploration boreholes and return drill water and was based on the inflow to the underground sump located approximately 280 feet inside the portal. The entire volume of underground drainage enters the sump and is ultimately reused as drill water for the ongoing exploration/development program. The water flow to the sump via the drainage ditches, which are excavated along the side of all drifts and ramps, includes both mine inflow and water pumped underground from the water supply well located in the facilities area. Based on the varying amounts of drilling water used at any time, and on the attenuation of flow along the more than 3,000 feet of drainage ditch (cumulative ditch length of more than 6,500 feet), a precise assessment of natural mine inflow is tenuous. However, based on seep flow data obtained and observations made during the underground evaluation of mid March, 1993, natural fracture inflow (i.e., not from surface boreholes or drill water) was estimated at 10 to 15 gpm.

Flow has decreased during the summer months and measured less than 10 gpm at its lowest point. Echo Bay geologists continue to map and monitor groundwater occurrences within the workings during the on-going exploration program.

2.0 INITIAL GEOCHEMICAL CHARACTERIZATION STUDIES

During the early planning stages of the Lamefoot Project, initial studies were completed to ensure that the on-going program would have the focus necessary to achieve the appropriate level of geochemical characterization. The initial stage of the Lamefoot geochemical characterization program is defined by Phases I through III:

Phase I	Geologic Evaluation;
Phase II	Identification and Characterization of Waste Rock Lithologies; and,
Phase III	Preliminary Acid Base Accounting Analysis.

The sections which follow provide a summary of the technical approach and results of the initial geochemical characterization efforts.

2.1 PHASE I - GEOLOGIC EVALUATION

As part of the internal pre-feasibility study completed by Echo Bay, a geologic evaluation of the waste rock, mine wall rock and backfill was initiated. Drill core collected in 1990 was logged by Echo Bay geologists to record geological properties including rock type, mineralogy, sulfide mineral abundance and distribution, the presence of fractures, and other characteristics which may influence geochemical behavior. The features noted during the core logging are summarized below:

- Lithology
- Alteration
- Mineralization
  - % Sulfides

  - Type
  - Style
  - Intensity
- Structure
  - Bedding
  - Faults/Shears
  - Fractures/Joints
  - Veins

  - Occurrence
  - Size
    - Habit
  -% Carbonates
    - Occurrence
  - Abundance
    - Reactivity

The geologic information was used to identify the various lithologies, and qualitatively identify the physical and geochemical properties of the waste rock and mine wall exposures which may influence effective surface and subsurface waste management. A major goal of the geologic evaluation was to establish preliminary lithologic classification of the rock types present at the Lamefoot Project.

Initial identification of waste/mine wall rock domains is generally based on lithologic subdivision, however the preliminary classification developed for Lamefoot was designed to identify the spatial variation in mineralization or alteration within each lithologic unit. In this manner, the range of potential variability in geochemical behavior will be evaluated. Thus, the preliminary geologic evaluation will allow the on-going geochemical testing program to focus on those domains which exhibit the greatest potential for both variability and acid generation.

In addition, underground mapping was initiated in 1991 to gather similar geologic information needed to construct geologic cross sections and longitudinal stope sections. The sections were developed to define the relative distribution and areas of exposure for the lithologies within the proposed stopes.

The following studies were also initiated for internal planning purposes;

- **Ore and Metallurgical Studies** - evaluation of process reagents and products, precious element mineralogy and distribution, deleterious trace element mineralogy, and metallurgical factors affecting concentrate grade, detailed evaluation of sulfide mineralogy, mineral composition, and ore textures.

- **Petrographic studies** - of the core samples were also performed to assist in mineral identification, and the evaluation of ore and mineral alterations.

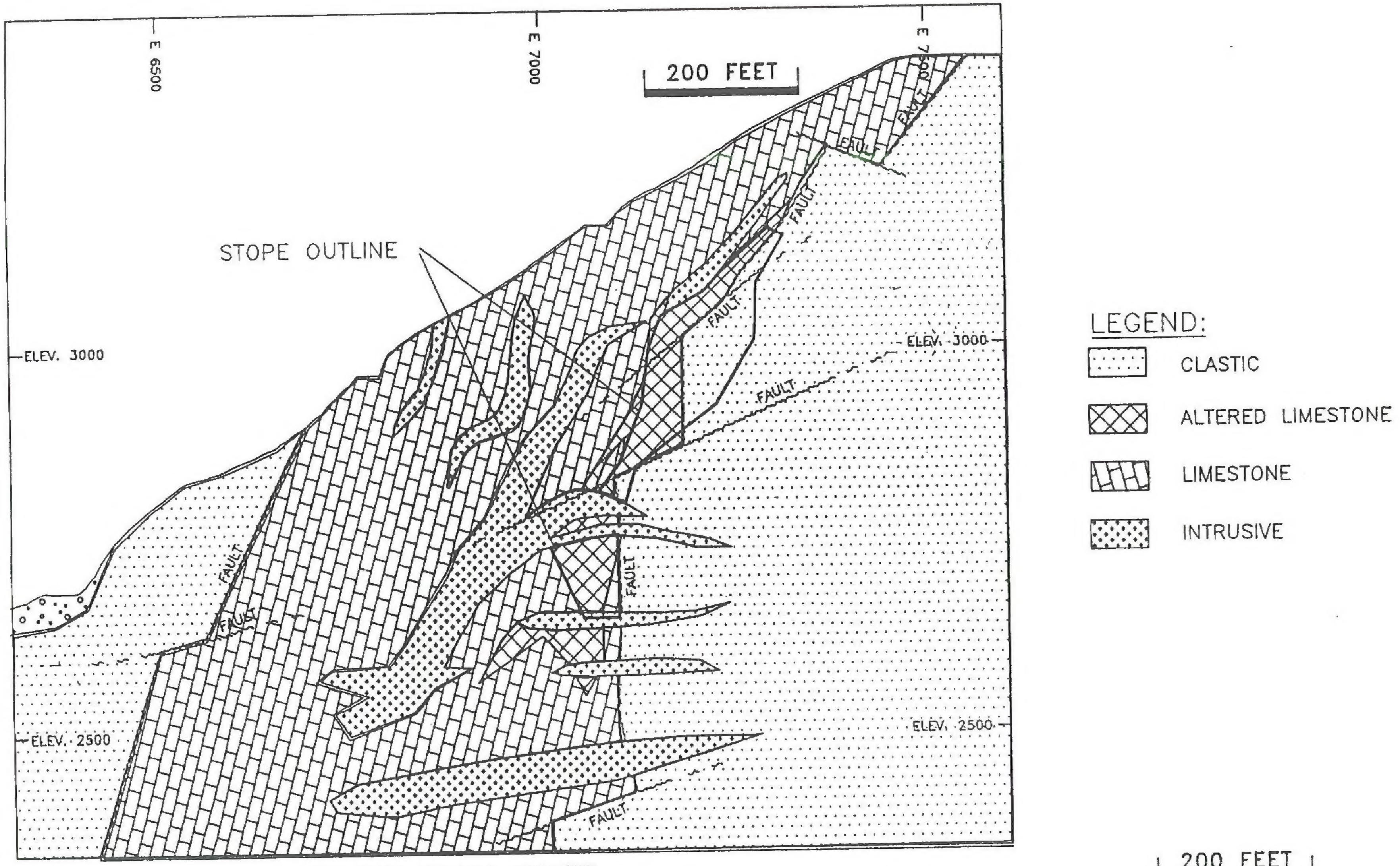
The metallurgical and mineralogical data were used to further characterize the mode of occurrence, habit, and other factors which potentially influence the geochemical behavior of the sulfide minerals. The data collected during this phase was used to provide the appropriate focus to the future phases of the Lamefoot waste characterization program in order to achieve effective implementation.

2.2 PHASE II - IDENTIFICATION AND CHARACTERIZATION OF WASTE AND MINE WALL ROCK LITHOLOGIES

2.2.1 Identification of Rock Lithologies

Based on the preliminary geologic investigations performed by Echo Bay, four general rock types were identified at the Lamefoot Project: limestone, low grade ore, intrusive, and clastic rocks. Lithologic descriptions for each of the rock types are presented below:

Limestone: Light to dark gray, massive with no apparent bedding, sandy to micritic in texture, locally sparitic, weak to moderate argillization, sulfides consist mainly of pyrite, sulfide occurrence



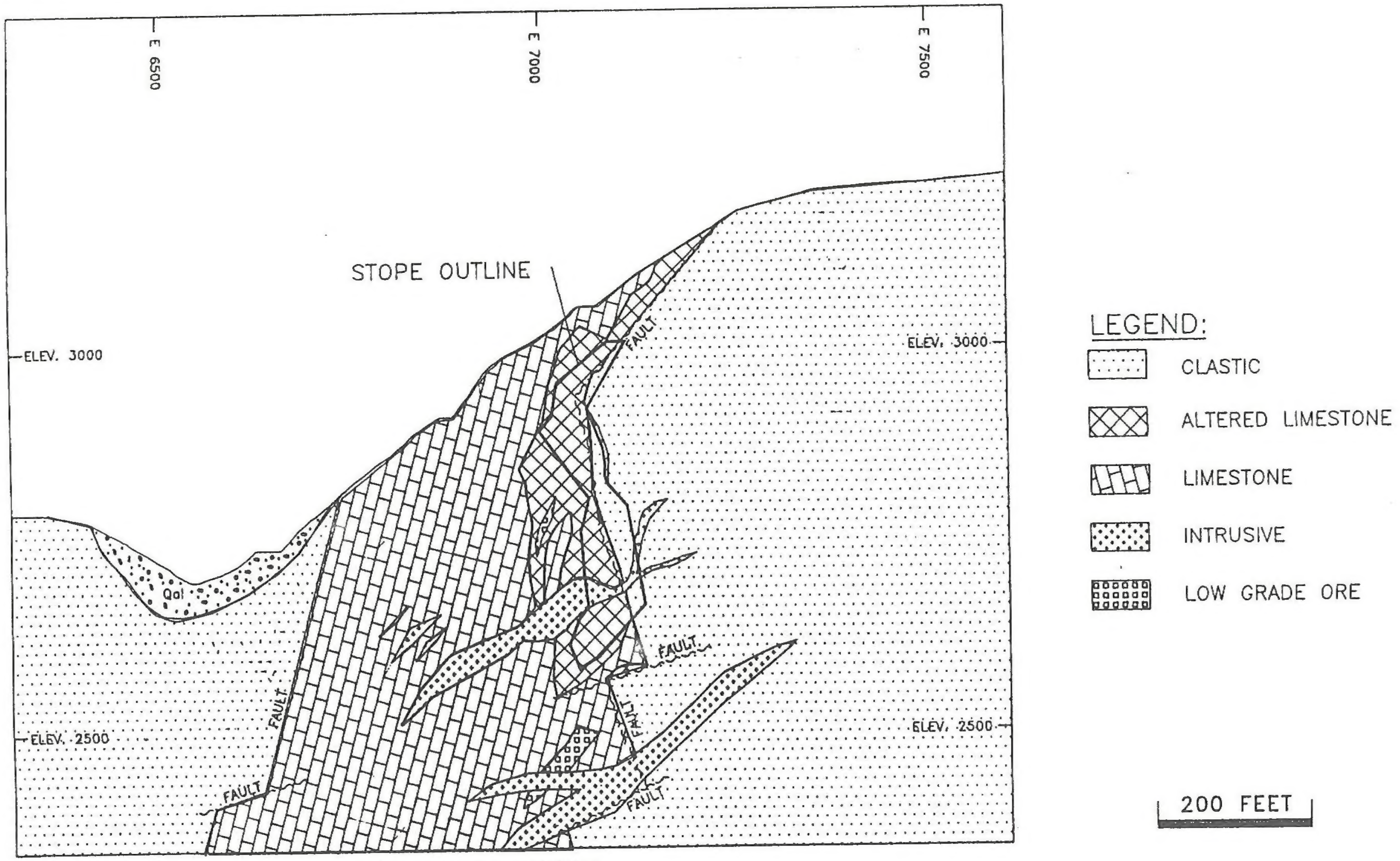
SECTION 26,100 NORTH
LOOKING NORTH

CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

Golder Associates

TITLE
GEOLOGIC CROSS SECTION
ILLUSTRATING THE DISTRIBUTION
OF WASTE ROCK LITHOLOGIES

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE
	J.C.	L.E.C.	NOV 1993	AS SHOWN		933-2614	261AGP	2-1



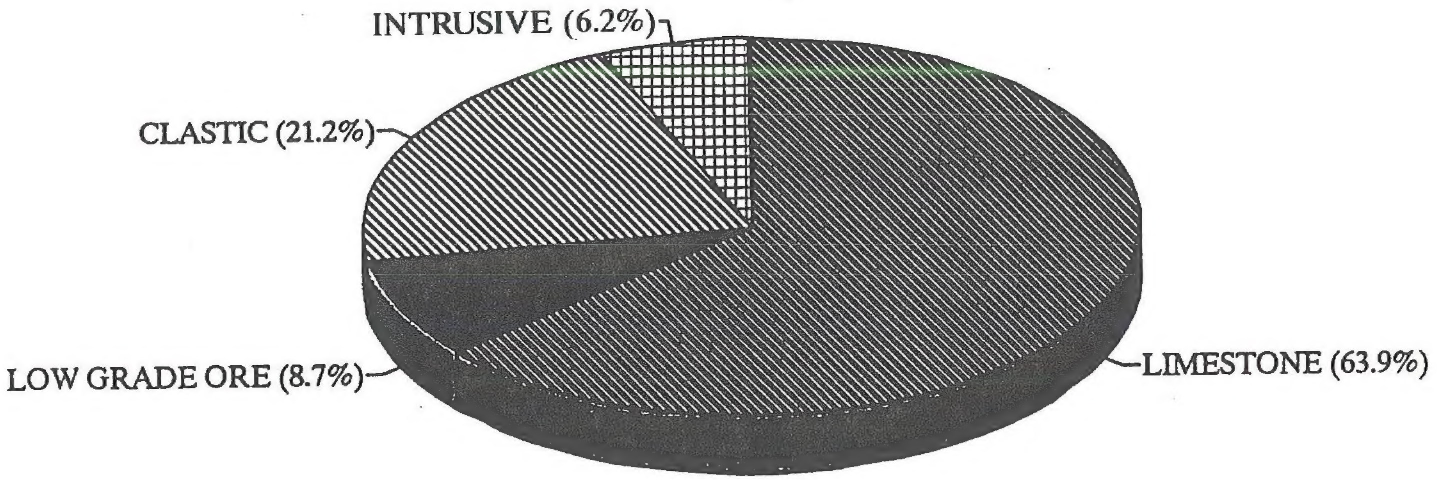
SECTION 26,900 NORTH
LOOKING NORTH

CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

Golder Associates

TITLE
GEOLOGIC CROSS SECTION
ILLUSTRATING THE DISTRIBUTION
OF WASTE ROCK LITHOLOGIES

DRAWN
CHECKED J.C.
REVIEWED L.F.C.
DATE NOV 1993
SCALE AS SHOWN
FILE NO.
JOB NO. 933-2614
DWG NO./REV.NO. 269AGP
FIGURE 2-2



CLIENT/PROJECT	ECHO BAY MINERALS Co. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON					TITLE	ESTIMATED WASTE ROCK PERCENTAGES	
DRAWN J.H.F.	CHECKED	REVIEWED	DATE NOVEMBER '93	SCALE AS SHOWN	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE 2-3

is limited to veins and veinlets. Sulfide habit is generally amorphous to euhedral, and visual quantities are estimated to range from trace to five percent.

Low Grade Ore: Dark greenish gray and brownish gray mottled altered limestone, sandy to micritic in texture, occasionally dolomitic, mineralized zones contain quartz veins and/or pervasive silicification with significant sulfides, magnetite, and/or hematite. Sulfide minerals consist primarily of pyrite which ranges in occurrence from massive to disseminated. Cumulative percentages of sulfide, magnetite, and/or hematite generally exceed 5 percent and in some areas can exceed 50 percent.

Clastic: Siliciclastic rock ranging from siltstone to sharpstone conglomerate, containing both greenstone and localized carbonate intervals. Sulfides consist primarily of pyrite and range from less than one percent to 10 percent depending on proximity to mineralization. Pyrite occurs mainly in veinlets and fractures with both calcite and quartz.

Intrusive: Porphyritic rhyodacite with biotite or hornblende. Alteration ranges from propylitic to argillitic with calcite and chlorite as common alteration products. Sulfide percentages range from zero to 0.1 percent and typically are disseminated throughout the groundmass.

Mine Backfill: Primarily composed of clastic and intrusive rock. Clastic rocks dominate and are siliciclastic siltstones, with variable amounts of sulfide and carbonate mineralization. Portions of the clastic rocks exhibit significant degrees of oxidation which generally decreases with depth. Visual sulfide percentages range from trace to 2 percent. Sulfide occurrence is primarily as fine grained disseminations within the matrix and quartz veins. The intrusive rocks are fine grained, with phenocrysts of biotite and feldspar, trace calcite and pyrite occur within veinlets and the groundmass.

The basic geologic environment of the Lamefoot deposit consists of a mineralized zone along the steeply dipping mineralized and healed Anfo fault. The fault is bounded on the east by clastic rocks and both unaltered and low grade ore (altered limestone) on the west. Economic mineralization extends into both the clastic and altered limestone rocks to varying degrees. Figures 2-1 and 2-2 illustrate typical cross sections near the north and south limits of the proposed mining area, respectively.

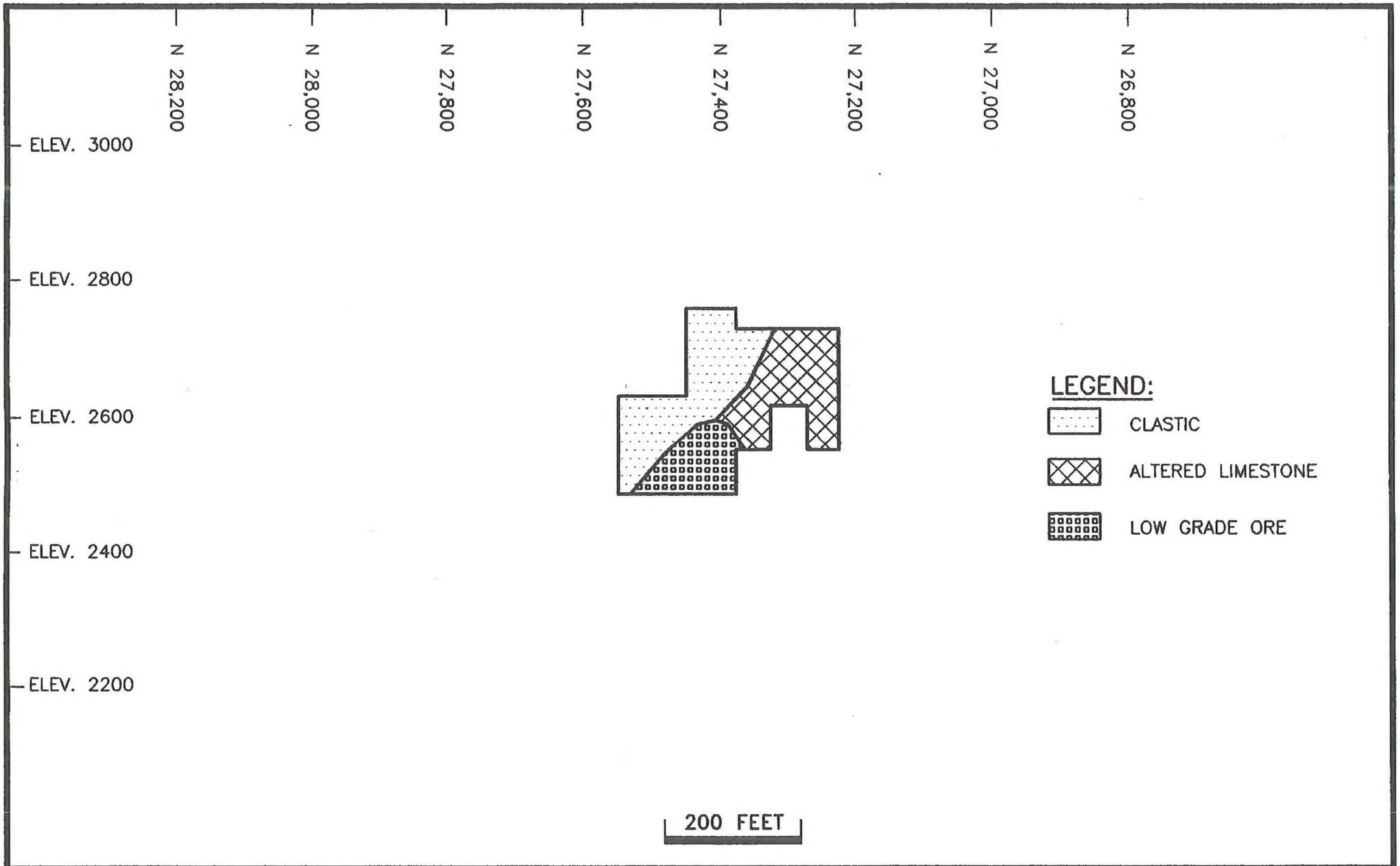
2.2.2 Waste Rock Volumes and Subsurface Lithologic Distribution

The relative proportions of the waste rock types were estimated based on the geologic logs and preliminary cross sections. A summary of the various lithologic proportions comprising the entire waste rock volume is illustrated in Figure 2-3. The limestone and clastic units comprise approximately 85 percent of the entire waste rock volume anticipated to be temporarily removed from the mine.

Data generated from surface core holes and the underground mapping were used to develop longitudinal sections of the proposed stoping areas in order to illustrate the relative distribution of lithologies. Figures 2-4 through 2-8 illustrate the relative abundance and location of the various rock types along the proposed stope walls. The west wall is dominated by low grade ore and unaltered limestone while the east wall is comprised almost entirely of clastic rock. The total surface area represented by the proposed stope walls is approximately 1.2 million square feet. The clastic, low grade ore, and unaltered limestone units comprise approximately 94 percent of the entire surface area.

2.3 PHASE III - PRELIMINARY ACID BASE ACCOUNTING ANALYSES

To determine, in a preliminary manner, whether ARD/AMD would be a potential concern at the site, and to assess potential geochemical variability between the Key and Lamefoot lithologies, Echo Bay completed

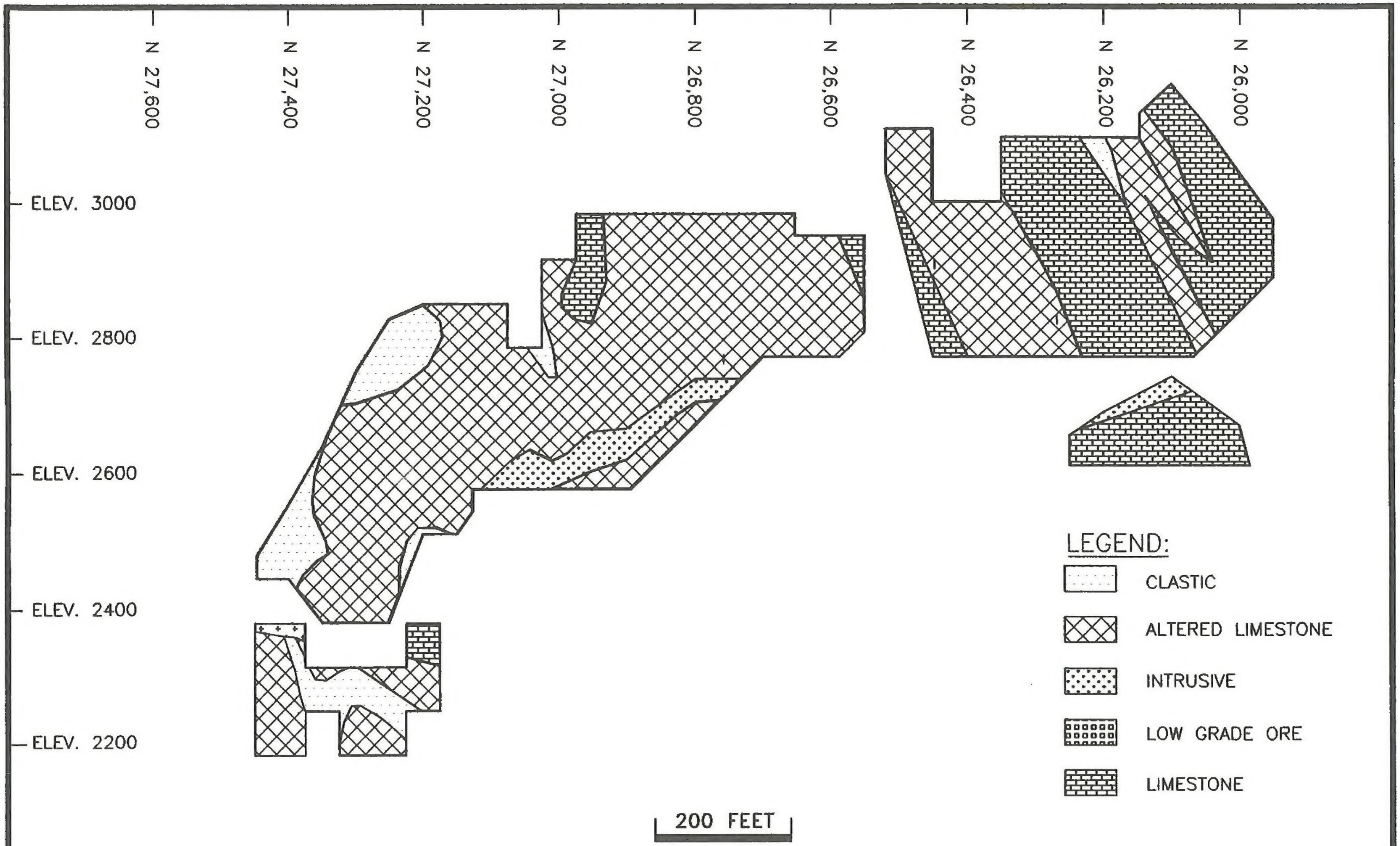


CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

Golder Associates
Denver, Colorado

TITLE
DISTRIBUTION OF WASTE ROCK LITHOLOGIES EAST WALL OF HW STOPE

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE
	J.C.	L.E.C.	AUGUST 1993	AS SHOWN		933-2614	A4	2-4

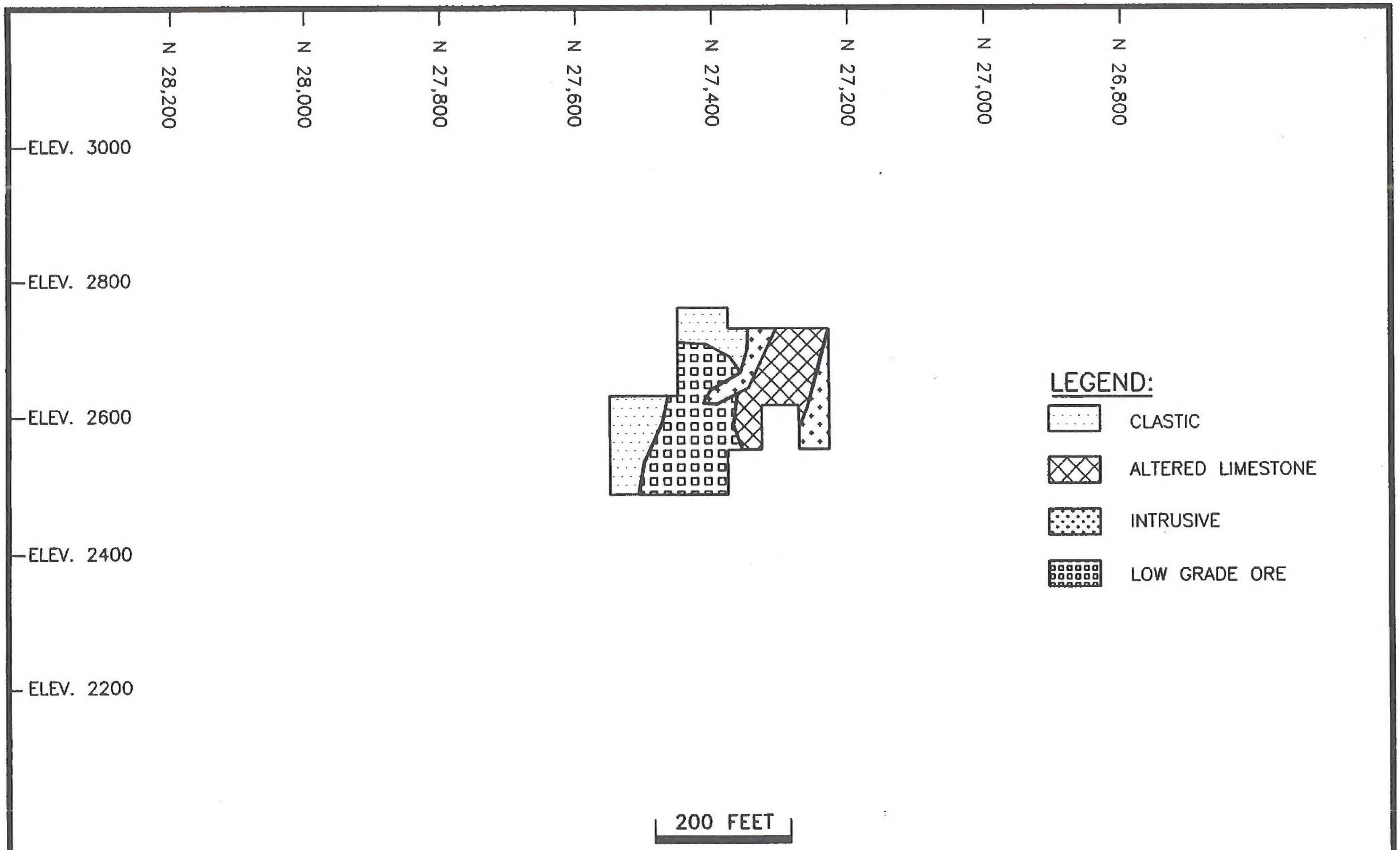


CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

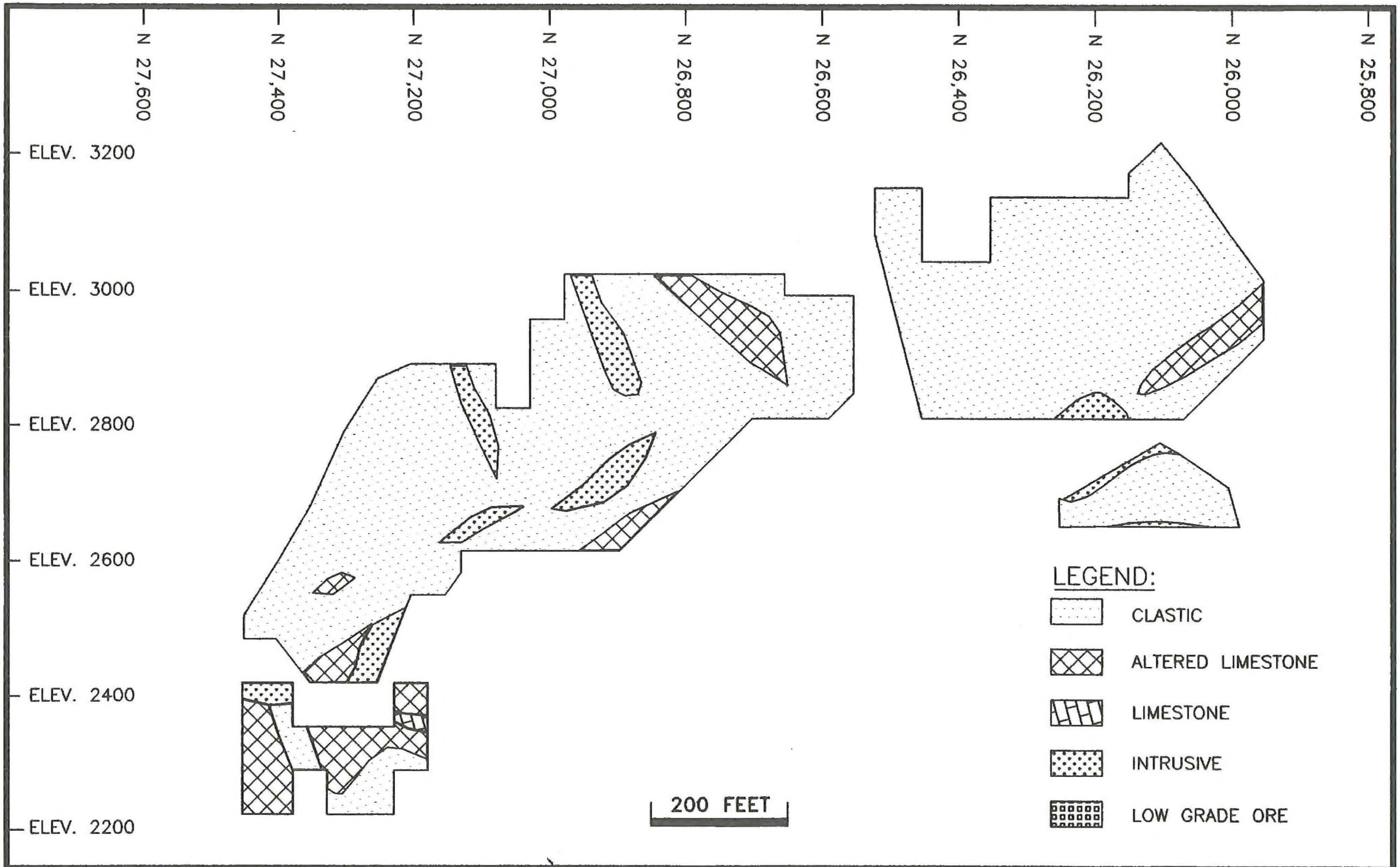
Golder Associates
Denver, Colorado

TITLE
DISTRIBUTION OF WASTE ROCK LITHOLOGIES WEST WALL OF MAIN STOPES

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE
	J.C.	L.E.C.	AUGUST 1993	AS SHOWN		933-2614	A6	2-5



CLIENT/PROJECT	ECHO BAY MINERALS Co. LAMEFOOT MINE KETTLE RIVER OPERATIONS REPUBLIC, WASHINGTON		Golder Associates Denver, Colorado			TITLE DISTRIBUTION OF WASTE ROCK LITHOLOGIES WEST WALL OF HW STOPES		
DRAWN	CHECKED J.C.	REVIEWED L.E.C.	DATE AUGUST 1993	SCALE AS SHOWN	FILE NO.	JOB NO. 933-2614	DWG NO./REV.NO. A3	FIGURE 2-6

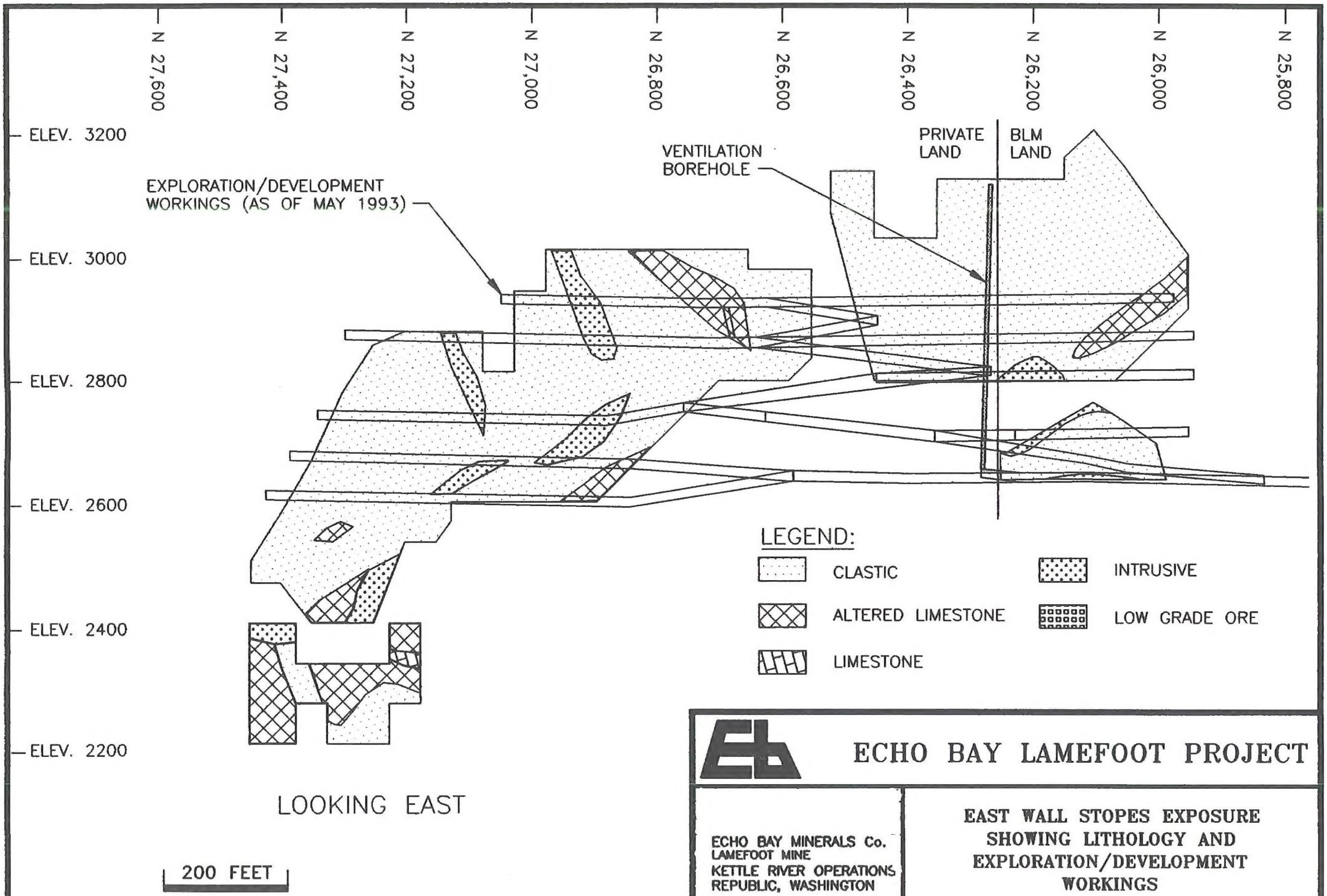


CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

Golder Associates
Denver, Colorado

TITLE
DISTRIBUTION OF WASTE ROCK
LITHOLOGIES EAST WALL
OF MAIN STOPES

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE
	J.C.	L.E.C.	AUGUST 1993	AS SHOWN		933-2614	A5	2-7



ECHO BAY LAMEFOOT PROJECT

ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

EAST WALL STOPES EXPOSURE SHOWING LITHOLOGY AND EXPLORATION/DEVELOPMENT WORKINGS

DATE	SCALE	FIG. NO. 2-8

933-2614-A10

acid base accounting tests on a number of waste rock samples in October, 1991. Tests were performed by Core Laboratories, located in Aurora, Colorado.

2.3.1 Sample Selection

The waste/mine wall rock samples selected for this preliminary testing satisfied the following criteria:

- The material will potentially report to the temporary waste rock placement area or be exposed in the stope walls of the underground mine.
- The degree of mineralization of a particular sample would, at a minimum, be representative of expected sulfide occurrence or provide a reasonably high bias to ensure an adequate degree of safety.
- The material was obtained from the area of the proposed stope or from rock which would report to the temporary waste rock placement area.

The methods used in sample selection consisted of:

- Evaluation of preliminary geologic cross-sections to determine the zones of ore and waste.
- Estimation of lithologic percentages comprising the waste rock material, based on examination of the geologic logs and preliminary cross-sections.
- Selection of core intervals and stope wall locations which reflected, to the greatest degree possible, the stratigraphic and spatial distribution within a given rock type.

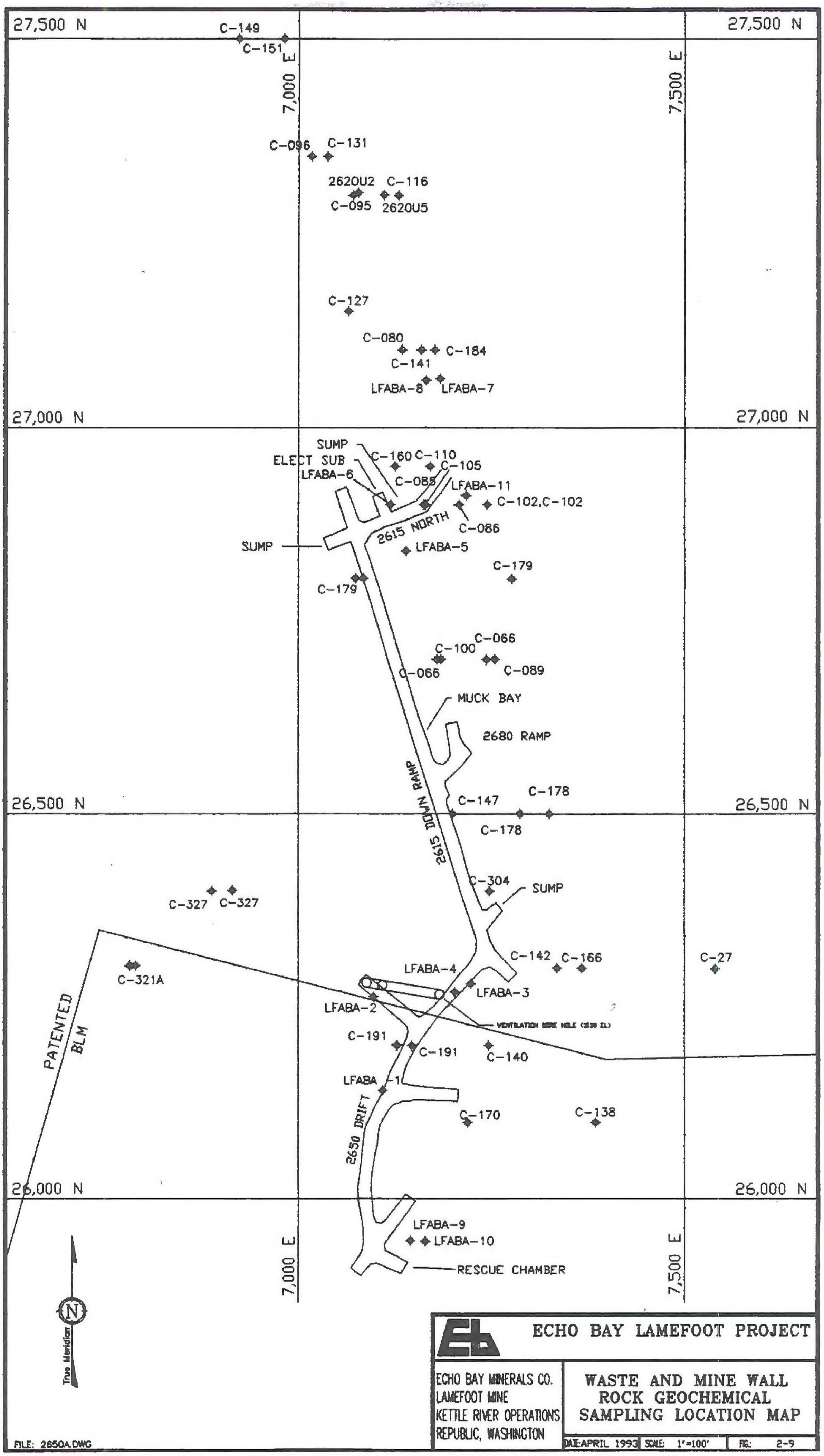
While every effort was made to satisfy the last point, the sampling of the stope walls and core intervals was spatially and mineralogically biased. The samples collected for the preliminary evaluation were collected at the stope boundary and as a result, are biased toward areas of increased mineralization. This was considered to be acceptable within the sampling program because the bias would integrate an additional factor of safety into the geochemical characterization. Therefore the samples submitted represent a "worst case" in terms of sulfide mineralization and acid generation potential.

2.3.2 Acid Base Accounting Procedures

A total of 11 waste/mine wall rock and 20 backfill samples were submitted for initial acid base accounting analysis (ABA). The waste/mine wall rock samples submitted for testing consisted of four clastic samples, one limestone sample, four altered limestone samples, and two intrusive samples. The sampling locations are illustrated on Figure 2-9. The geologic logs for the waste/mine wall rick and backfill samples submitted are presented in Tables 2-1 and 2-2, respectively. The following paragraphs summarize the test procedures, limitations and results for the waste rock and backfill acid base accounting.

Acid Base Accounting Procedures

ABA testing begins with a measurement of total sulfur in a sample, by nitric acid oxidation and subsequent titration (Sobek et al. 1978). The acid generation potential (AGP) of the waste material is then calculated from total sulfur content to tons $CaCO_3$/kiloton (TCaCO3/kT) of rock. The stoichiometric conversion used involves the oxidation of pyrite (FeS_2) and subsequent liberation and hydrolysis of iron (Fe) as illustrated by the reaction below [1].



ECHO BAY LAMEFOOT PROJECT

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

WASTE AND MINE WALL ROCK GEOCHEMICAL SAMPLING LOCATION MAP

DATE: APRIL 1993 SCALE: 1"=100' FIG: 2-9

FILE: 2650A.DWG

TABLE 2-1

SUMMARY OF WASTE/MINE WALL ROCK SAMPLES SUBMITTED FOR PHASE III ACID BASE ACCOUNTING ANALYSIS

LFABA Number	Rock Type	Sample Location			Geologic Description
		Northing	Easting	Elevation	
1	Low Grade Ore	26142	7110	2655	Altered limestone, trace hematite, trace pyrite, disseminated and in microfractures.
2	Intrusive	26263	7098	2655	Biotite rhyodacite, propylitically altered, trace carbonate mineralization occurring in veinlets.
3	Clastic	26280	7224	2650	Clastic, silicic, trace pyrite in veinlets, and disseminations, trace carbonate mineralization.
4	Intrusive	26269	7203	2722	Biotite rhyodacite, minimal alteration, trace pyrite occurring in veinlets.
5	Low Grade Ore	26840	7140	2755	Altered limestone, trace hematite, trace magnetite, trace calcite, fractured.
6	Low Grade Ore	26900	7120	2615	Massive hematite and magnetite, trace carbonate mineralization, 2% pyrite in veinlets.
7	Clastic	27063	7184	2620	Clastic, silicic, 2-5% pyrite in veinlets and microfractures, some disseminations.
8	Low Grade Ore	27061	7166	2620	Altered limestone, 60% massive hematite and magnetite, trace sulfide mineralization.
9	Clastic	25945	7146	2730	Clastic, sharpstone, quartz veining with trace pyrite disseminated throughout.
10	Limestone	25944	7165	2730	Limestone, unaltered, weak microfracturing, trace sulfide mineralization consisting of disseminated pyrite.
11	Clastic	26912	7218	2745	Clastic, siltstone/sharpstone, minor quartz veining, 2-5% pyrite in veinlets and as disseminations.

TABLE 2-2

GEOLOGIC LOGS FOR BACKFILL EXPLORATION HOLES

Borehole Name	Depth (fbgs*)	Geologic Description
LR-1	0-10'	Overburden
	10-50'	Intrusive (Scatter Creek)
		- fine grained, medium green
		- local small biotite phenocrysts
		Possible coarse, psdomorphs of feldspar phenocrysts
		- trace calcite
		- local trace fine disseminated pyrite
	50'	End of hole
LR-2	0-5'	Overburden
	5-60'	Intrusive, medium green, fine grained with occasional biotite phenocrysts
		- minor irregular plagioclaise phenocrysts
		- minor carbonate (calcite)
	60-80'	- local trace disseminated pyrite
	80'	Clastic, fine grained, mixed oxidized material with very fine grained siliceous (chert) pyritic rock
		Similar to 60-80' except for increased very fine grained siliceous material.
		- weakly to moderately pyritic
	110-130'	- local moderate oxidation - presumably from sulfides
	130-	Increased amount of oxidized material possibly masking pyritic siliceous rock (very little apparent).
	180'	Similar to 80-110'; mixed gray clastic
		- fine grained but less siliceous and pyritic with oxidized fine grained rock
		- clastics exhibit a subtle "blocky" texture due to parting on foliation (bedding) planes and a probable cross cutting fabric
	180-220'	Decreased oxidized rock, predominary light gray clastic, weakly siliceous
		- strongly pyritic w/abundant disseminated pyrite (1-2%)
		- sulfide occurrence appears to be locally controlled by cross cutting thin silica veinlets
	220'	- continued subtle blocky texture described above
		End of hole

TABLE 2-2
(Concluded)

Borehole Name	Depth (fbgs*)	Geologic Description
LR-3	0-5'	Overburden
	5-110'	Primarily dark gray to brownish fine grained clastic - possible siltstone. - minor oxidation - generally more prevalent in the uphole portions - little to no sulfide visible - local minor light colored, more siliceous clastics - possible thin interbeds in the siltstones; the lighter colored clastics commonly are very weakly pyritic
	110-130'	Predominantly lighter gray relative to uphole; increased silica with sulfides. - subtle blocky texture probably due to clastics parting on bedding planes - trace silica veining
	130'	End of hole

*fbgs - Feet below ground surface

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3 + 2SO_4^{-2} + 4H^+ \qquad [1]$$

Total sulfur has been used for this analysis rather than pyritic sulfur because there are no other sulfur bearing minerals (i.e., barite, jarosite or alunite) found in significant amounts within the waste rock which could result in positive interference. Using total sulfur ensures that an additional factor of safety is incorporated into the method of evaluation. In some instances the mineralogy of the waste rock is such that this is an overly conservative factor of safety. However, based on the current understanding of the Lamefoot mineralogy, using total sulfur to evaluate acid generation potential provides an acceptable level of safety and is consistent with the method of evaluation used in the Key Expansion program.

The acid neutralizing potential (ANP) is a function of reactions which liberate hydroxyl (OH-) and carbonate (HCO_3^- and CO^{-2}) ions. These reactions include the dissolution of carbonates [2] and desorption of alkali cations and breakdown of silicate minerals to clays [3].

$$4H^+ + 2CaCO_3 \rightharpoonup 2Ca^+ + 2CO_2 + 2H_2O \qquad [2]$$
$$CaAl_2Si_2O_8 + 2H^+ + H_2O \rightharpoonup Al_2Si_2O_5(OH)_4 + Ca^{+2} \qquad [3]$$

The ANP is determined by measuring experimentally, the quantity of acid consumed by a finely ground sample of waste material. The total acid consumed is then converted to tons $CaCO_3$/kT waste material.

The Net Neutralization Potential (NNP) of a waste material is subsequently calculating using the following equation [4]:

$$NNP = ANP\text{-}AGP \qquad [4]$$

A negative NNP value indicates that the waste material is potentially acid producing while a positive NNP value indicates an excess of neutralization potential. Because the NNP is expressed in $CaCO_3$ equivalents, the value represents the amount of pure (100% $CaCO_3$) that would be necessary to add to 1000 tons of waste material to neutralize all acidity produced.

2.3.3 Interpretation of ABA Results

An ABA test determines the total amount of sulfur in all forms present in a material, including sulfide-sulfur. In calculating the AGP, all the sulfide present is assumed to be pyrite. This is a valid assumption for the sulfide mineralization present at Lamefoot. The extensive geologic data indicate that pyrite is the dominant sulfide mineral present with minor amounts of pyrrhotite and chalcopyrite. The maximum AGP is determined assuming all pyrite will weather and produce acid by reaction [1]. Similarly, the ANP determines the amount of acid a material can neutralize [reactions 2 and 3] by measuring the acidity consumed during a titration procedure. The NNP is then calculated by subtracting the AGP from the ANP.

Given the potential ambiguity and somewhat subjective nature of interpretation of ABA data when used to determine the potential for acid generation in field conditions, several criteria have been developed to predict if a sample will produce acid in the field. In one interpretation, a NNP value of $<$-20 T $CaCO_3$/kT represents a net acid-producing material (Group 1) while a NNP value of $>$20 T $CaCO_3$/kT represents a net neutralizing material (Group 3). NNP values between -20 and 20 T $CaCO_3$/kT suggest an uncertain potential for acid generation (Group 2) (B.C. Acid Rock Drainage Task Force 1989).

Another method for interpretation of acid base accounting is the evaluation of the ANP:AGP ratio. Based on experience with laboratory tests and field data on a wide range of sulfur bearing rock types, there appears to be a low potential for acid generation for waste rock samples with an ANP:AGP ratio greater than or equal to 3:1 (Group 3). Waste rock samples with a ratio of less than 1:1 (Group 1) have an increased potential to generate acid. Those waste rock sampled with ANP:AGP ratios between 1:1 and 3:1 (Group 2)

TABLE 2-3

SELECTED EVALUATION CRITERIA FOR THE LAMEFOOT ACID-BASE ACCOUNTING ANALYSES

	NNP	ANP:AGP
Strong Acid Generation Potential		
Group 1	NNP <-20 $TCaCO_3/kT$	ANP:AGP < 1.0
Uncertain Acid Generation Potential		
Group 2	-20 $TCaCO_3/kT \leq$ NNP ≤ 20 $TCaCO_3/kT$	$1.0 \leq$ ANP:AGP ≤ 3.0
Low Acid Generation Potential		
Group 3	NNP > 20 $TCaCO_3/kT$	ANP:AGP > 3.0

have an acid generation potential which is difficult to predict (Brodie et al. 1991; and, Smith 1992). These three groups were developed to conservatively represent responses expected in the field given the inherent inaccuracies in extrapolating acid base accounting results to field scale situations.

The method used to interpret ABA results for the Lamefoot samples consisted of dividing the samples into three categories based on their NNP and ANP:AGP values. As mentioned above, all AGP values were determined assuming the total sulfur contained within a sample to be pyritic sulfur. Table 2-3 summarizes the criteria used to evaluate the Lamefoot ABA data.

2.3.4 Limitations

Although the ABA test has some shortcomings, it provides one of the best, most cost-effective approaches to initial evaluation of geochemical behavior. ABA test results are generally considered conservative because they assume the total sulfur content of a material (S-total) to be sulfide-sulfur (S-pyrite).

The actual geochemical behavior of the waste materials is not considered by static testing (i.e., ABA tests) which provides a total mass balance of acid generating and neutralizing materials. Following the discussion above, it is necessary to consider environmental factors that are not addressed in the testing.

Although, the ABA values for a material may indicate that there is a strong likelihood for the production of acid associated with the weathering of a material, several factors will serve to decrease the actual amount of acid produced compared to the amount predicted by the NNP. Acid producing potentials determined from ABA data are conservative in that the sample grain size used for the analysis is minus 60 (or -200) mesh compared to the larger size fractions (generally 1/4 to 6 inches or larger) for typical mined ore and waste material. In a large particle, much of the pyrite will be bound within the rock matrix and unavailable for oxidation. As the size fraction decreases, the effective surface area increases and hence, the reactivity of a given sample increases. Thus, the surface area and reaction rate associated with the laboratory sample are much greater than that of the actual on site material in the field.

The ABA test also assumes that all pyritic sulfur will weather and all iron produced will ultimately undergo hydrolysis and form $Fe(OH)_3$. This results in a maximum production of 4 moles of H^+ for every mole of pyrite weathered [Reaction 1]. In a natural system, it is unlikely that all pyrite will react or that all the iron liberated will precipitate as $Fe(OH)_3$. In addition, iron will form other sulfate and carbonate minerals, depending on pH, and may also co-precipitate in these mineral forms with other metals, rendering the iron unavailable for hydrolysis and the subsequent formation of $Fe(OH)_3$.

In addition to unreactive pyrite contained within the rock matrix, some pyrite will not weather due to the precipitation of iron hydroxides on the surface of the pyrite crystals, rendering them non-reactive. This is especially true in a low flux environment where the reaction products are not subject to transport. Likewise, it is important to note that the acid generating potential can be under estimated due to the precipitation of iron hydroxide, and potentially gypsum, on the surfaces of acid neutralizing minerals.

The tendency for a material to produce acid is also strongly site specific and determined by factors including climate, associated lithologic and sulfide mineralogy, design and mitigative measures, and soil and rock buffering capacity. Design measures such as placing potential acid-producing materials above or within potential acid-neutralizing materials have the capacity to produce neutral drainage.

Soil systems are inherently moderate to well buffered. Thus, all H^+ ions produced will not necessarily result in a decrease in solution pH. Some H^+ ions will be involved in precipitation and dissolution reactions with metals and other ions in solution and on exchange sites, decreasing the amount of H^+ in solution. Although there may be a limited neutralization capacity, there may be a considerable buffering capacity.

Finally, the ABA test does not consider the kinetics of acid producing or neutralization reactions. Thus, a material may appear to be acid producing based on ABA results, but the rate of acid producing reactions and may be slower than neutralizing reactions. Likewise, an apparently neutral material may produce acid if neutralization reactions are kinetically limited, particularly if the amount of pyritic-S is significant (>1%). Therefore, the usefulness of ABA data is only in a descriptive context and not predictive unless combined with kinetic testing. Kinetic testing confirms the accuracy of the criteria established to evaluate ABA data in predicting potential geochemical behavior. The kinetic testing performed during the Key Expansion waste characterization program confirmed that the ABA data for the waste rock lithologies could be safely used in a predictive context. In fact, the criteria established to evaluate the ABA data for the Key Expansion (and hence the Lamefoot Project) provided a conservative framework appropriate for minimizing, to the largest degree, potential environmental impacts.

2.4 RESULTS

The results of the acid base accounting analyses for the 11 initial waste/wall rock samples and 20 potential backfill samples are presented in Tables 2-4 and 2-5, respectively. The paragraphs which follow discuss the results for each of the waste/wall rock lithologies at Lamefoot. In addition, these results are compared to the ABA results for the equivalent Key Expansion waste rock types in order to illustrate potential geochemical similarities and differences.

Clastic

Total sulfur values of the four Lamefoot clastic samples ranged from 0.72 to 7.03 percent, with a geometric mean of approximately 2.57 percent. Each of the samples has significant amounts of neutralization capacity with ANP values ranging from 51.6 to approximately 73 $TCaCO_3/kT$, and a geometric mean of 63 $TCaCO_3/kT$. The NNP values for the clastic samples range from -158.1 to 50.3 $TCaCO_3/kT$, while the ANP:AGP ratios range from 0.28 to 3.23 with a geometric mean of 0.78. Three samples (LEAG-3, LFABA-9, and LFABA-11) had NNP values less than -20 $TCaCO_3/kT$ and ANP:AGP ratios less than 1 suggesting a strong acid generation potential. These samples are subsequently classified as Group 1 materials. The remaining sample (LFABA-7) is classified as Group 3 with an NNP value greater than 20 $TCaCO_3/kT$ and a ANP:AGP ratio greater than 3.0.

The range of total sulfur values for the Lamefoot clastic samples is comparable to that of the Key Expansion clastic samples. Total sulfur values for the Key Expansion clastic samples range from less than 0.01 to 3.06 percent with a mean of 0.32 percent. ANP values for the Key Expansion clastic samples range from 27.7 to 217 $TCaCO_3/kT$ and have a geometric mean of 45.5 $TCaCO_3/kT$. Therefore, the preliminary acid base accounting data suggest that the selected Lamefoot clastic samples contain slightly higher total sulfur and greater neutralizing capacity when compared to the Key Expansion clastic samples. Additional clastic samples have been submitted for acid base accounting in order to characterize the degree of variability within the clastic unit present at the Lamefoot Project. A discussion of the additional testing is presented in Section 3.0.

Limestone

One limestone sample was submitted for acid base accounting (LFABA-10). The total sulfur is approximately 1.9 percent, while the NNP and ANP:AGP values are 404.9 $TCaCO_3/kT$ and 7.85, respectively. The limestone present in wall rock at Lamefoot is subsequently classified as a Group 3 material, with a negligible potential for acid generation and a significantly high acid neutralization capacity. The mean total sulfur content for the Key Expansion limestone is approximately 0.1 percent, suggesting that the selected limestone sample from the Lamefoot site contain a higher percentage of sulfide mineralization. Because of the high degree of acid neutralizing capacity, it is not anticipated that this is a significant amount of sulfide mineralization relative to expected geochemical behavior. Additional samples have been submitted for acid

TABLE 2-4

RESULTS OF PHASE III ACID-BASE ACCOUNTING ANALYSIS OF WASTE/MINE WALL ROCK SAMPLES

Sample Name	Sample Lithology	Total Sulfur (%)	AGP $TCaCO_3/kT$	ANP $TCaCO_3/kT$	NNP $TCaCO_3/kT$	ANP:AGP Ratio
LFABA #1	Low Grade Ore	0.02	0.6	475	474.4	791.6
LFABA #2	Intrusive	1.00	31.2	332	300.8	10.6
LFABA #3	Clastic	2.79	87.2	51.6	-35.6	0.59
LFABA #4	Intrusive	0.42	13.1	177	163.9	13.51
LFABA #5	Low Grade Ore	0.01	0.3	439	438.7	1.463
LFABA #6	Low Grade Ore	1.65	51.6	434	382	8.41
LFABA #7	Clastic	0.72	22.5	72.8	50.3	3.23
LFABA #8	Low Grade Ore	0.82	25.6	210	184.4	8.20
LFABA #9	Clastic	3.08	96.2	68.0	-28.2	0.70
LFABA #10	Limestone	1.89	59.1	464	404.9	7.85
LFABA #11	Clastic	7.03	220	61.9	-158.1	0.28

TABLE 2-5

RESULTS OF PHASE III ACID BASE ACCOUNTING OF LAMEFOOT BACKFILL SAMPLES

Core Hole	Depth Interval (fbgs)[1]	Totals %	AGP $TCaCO_3$/kT	ANP $TCaCO_3$/Kt	NNP $TCaCO_3$/kT	ANP:AGP
LR-1	0-20	0.096	3	37	34	12.3
	20-40	<0.01	<0.01	67	67	>67
	40-50	<0.01	<0.01	66	66	>66
LR-2	0-20	<0.01	<0.01	51	51	>51
	20-40	<0.01	<0.01	45	45	>45
	40-60	0.22	7	61	54	7.7
	60-80	0.51	16	43	27	2.7
	80-100	1.44	45	44	-1	0.98
	100-120	2.81	88	43	-45	0.48
	120-140	0.70	22	20	-2	0.90
	140-160	1.95	61	67	6	1.09
	160-180	0.29	9	25	10	1.56
	180-200	0.93	29	71	42	2.45
	200-220	0.99	31	81	50	2.61
LR-3	0-20	0.25	8	33	25	4.12
	20-40	0.54	17	47	30	2.76
	40-60	0.93	29	69	40	2.37
	60-80	0.32	10	53	43	5.3
	80-100	0.38	12	50	38	4.16
	100-120	0.42	13	50	37	3.84

Note: [1]fbgs = Feet Below Ground Surface base accounting in order to characterize the potential variability in the limestone present at the Lamefoot site. A discussion of the additional testing is presented in Section 3.0.

Low Grade Ore

The total sulfur values of the four low grade ore samples submitted for acid base accounting range from 0.01 to 1.65 percent with a geometric mean of 0.13 percent. NNP values range from 184 to 474 $TCaCO_3/kT$ while ANP:AGP ratios range from 8.20 to 1,463 indicating that the low grade ore, which is composed of altered limestone, has a negligible potential to generate acid and a significantly high neutralization potential (Group 3).

Intrusive

Total sulfur values for the two intrusive samples submitted for acid base accounting range from 0.42 to 1.0 percent, with a geometric mean of 0.65 percent. NNP values range from 164 to approximately 301 $TCaCO_3/kT$, while ANP:AGP values range from 10.6 to 13.5. This indicates that the intrusive waste rock has no significant potential for acid generation (Group 3) and the neutralizing capacity is in excess of the maximum potential acidity. The intrusive waste rock at the Key Expansion exhibited the same characteristics relative to the potential for acid generation. Total sulfur values for the Key Expansion intrusives range from less than 0.01 to 0.07 percent with a geometric mean of 0.013 percent. ANP:AGP ratios for the Key Expansion intrusive waste rock range from 35.7 to 303.3 suggesting that the selected Lamefoot intrusive samples have slightly higher total sulfur contents and slightly lower acid neutralizing potential.

Backfill

Total sulfur values for the potential backfill range from less than 0.01 to 2.81 percent with a geometric mean of approximately 0.25 percent. NNP values range from -45 to 67 $TCaCO_3/kT$ while ANP:AGP values range from 0.48 to greater than 67.0. Of the 20 samples submitted three are classified as Group 1, seven as Group 2 and 10 as Group 3. The results of the acid base accounting analysis for the backfill samples are summarized on Table 2-4. Based on the geologic descriptions and acid base accounting data it appears that the clastic rocks comprising the backfill correlate to the Clastic I domain present at the Key Expansion.

2.5 SUMMARY OF PHASE III PRELIMINARY ACID BASE ACCOUNTING

2.5.1 Waste/Mine Wall Rock Samples

Eleven waste/mine wall rock samples were submitted for preliminary acid base accounting. Table 2-6 provides a summary of the results relative to the criteria defined in Section 2.3.3. The laboratory results appear in Appendix A. Three of the eleven samples were subsequently classified as Group 1 materials with a strong potential to generate acid. All of these Group 1 samples were from the clastic lithology. The limestone, low grade ore, and intrusive samples are all classified as Group 3 materials and show negligible acid generation potential and significant amounts of neutralization capacity. No Group 2 samples were identified through the preliminary analysis. The Group 3 lithologies represent approximately 79 percent of the total waste rock volume and 54 percent of the expected mine wall exposure area. The clastic lithology comprises approximately 21 percent of the total waste rock volume and 46 percent of the expected mine wall exposure area. Given the magnitude of the neutralizing capacity of the remaining 79 percent of the waste rock, it is not anticipated that the temporary waste stockpiles will represent a significant source of potential acid generation. The continuing waste characterization work (Section 3.0) focused on defining what portion of the clastic rock has the highest potential for acid generation (i.e., develop additional waste rock domains based on geochemical homogeneity). In addition, subsequent phases were designed to emphasize the characterization of the AMD potential from the mine wall rock.

TABLE 2-6

ABA RESULTS RELATIVE FOR THE WASTE/MINE WALL ROCK SAMPLES RELATIVE TO THE EVALUATION CRITERIA

Waste/Mine Wall Rock Lithology	Number of Samples Submitted	Evaluation Criteria NNP	 ANP:AGP
		Geochemical Classification	
Limestone	1	(1) Group 3	(1) Group 3
Low Grade Ore	4	(4) Group 3	(4) Group 3
Clastic	4	(3) Group 1 (1) Group 3	(3) Group 1 (1) Group 3
Intrusive	2	(2) Group 3	(2) Group 3
TOTAL	11		

Notes: NNP reported as $TCaCO_3/kT$
( ) refers to the number of samples in a particular group

TABLE 2-7

ABA RESULTS FOR THE BACKFILL SAMPLES RELATIVE TO THE EVALUATION CRITERIA

Geochemical Classification	Evaluation Criteria	
	NNP	ANP:AGP
Group 1	LR-2 (100-120)	LR-2 (80-100) LR-2 (100-120) LR-2 (120-140)
Group 2	LR-2 (80-100) LR-2 (120-140) LR-2 (140-160) LR-2 (160-180)	LR-2 (60-80) LR-2 (140-160) LR-2 (160-180) LR-2 (180-200) LR-2 (200-220) LR-3 (20-40) LR-3 (40-60)
Group 3	LR-1 (0-20) LR-1 (20-40) LR-1 (40-50) LR-2 (0-20) LR-2 (20-40) LR-2 (40-60) LR-2 (60-80) LR-2 (180-200) LR-2 (200-220) All LR-3 Samples	All LR-1 Samples LR-2 (0-20) LR-2 (20-40) LR-2 (40-60) LR-3 (0-20) LR-3 (60-80) LR-3 (80-100) LR-3 (100-120)

In general, the total sulfur values of the 11 samples collected from the various rock lithologies were higher than those found at the Key Expansion site. As mentioned above, the samples collected for the preliminary evaluation were collected at the stope boundary and as a result, are biased toward areas of increased mineralization. This was considered to be acceptable within the sampling program because the bias would integrate an additional factor of safety into the waste characterization. The samples submitted therefore represent a "worst case" in terms of sulfide mineralization and acid generation potential. Several additional factors which result in establishing a high degree of conservativeness include the following:

- Use of total sulfur values to calculate the AGP effectively overestimates the maximum potential acidity of a particular sample.
- Assuming that all sulfide minerals present will be available for reaction and the oxidation of the sulfide minerals will go to completion.
- Procedural characteristics of the acid base analytical method over-estimate the magnitude of sulfide oxidation by increasing the effective surface area and using a more aggressive oxidizing agent than found in natural systems.

As a result of the initial acid base accounting a significant amount of variability within the clastic domain was identified. In addition, this lithology has the highest potential for acid generation of the four waste rock types. In order to characterize the variability and to further define potential geochemical domains within this unit, additional samples were selected and submitted for acid base accounting analysis as part of Phase IV and V of the geochemical characterization. In addition, as part of the continuing waste characterization program developed for the Lamefoot Project, additional samples from the limestone, altered limestone, low grade ore, and intrusive waste rock lithologies were submitted for testing.

2.5.2 Backfill Samples

Twenty samples collected from the potential backfill were submitted for acid base accounting analysis. Table 2-7 provides a summary of the results relative to the established evaluation criteria. Based on the ANP:AGP criteria, three of the samples are considered to have a strong potential for acid generation (Group 1), seven of the samples have an uncertain acid generation potential (Group 2), and 10 of the samples have negligible acid generation potential and significant neutralization potential. When evaluated relative to the NNP criteria, one sample has a strong acid generation potential (Group 1), four samples have uncertain acid generation potential (Group 2), and 15 samples have significant neutralization potential. A comparison of the geologic logs for the Clastic I lithology at the Key Expansion with those clastic descriptions from the backfill exploratory boreholes suggest a distinct similarity. The acid base accounting data indicate comparable sulfur contents and neutralizing capacity, further supporting the similarity of the clastic rocks between the two sites.

Variability of results can be accounted for by weathering and vertical distribution of oxidation. These characteristics are noted on the geologic logs (Table 2-2) and as a result identification of these zones on a visual basis is facilitated making identification in the field possible.

3.0 CONTINUING WASTE CHARACTERIZATION PROGRAM

Beginning in 1993, the second portion of the phase waste characterization program was implemented and consists of the following elements:

- Phase IV - Selection of Additional Mine Wall Rock Samples;
- Phase V - Secondary Acid Base Accounting Laboratory Analysis;

- Phase VI - Definition of Geochemical Mine Wall Rock Domains; and,
- Phase VII - Geochemical Correlation with Key Expansion.

A brief discussion of each element of the waste characterization program is presented below.

3.1 PHASE IV - SELECTION OF ADDITIONAL MINE WALL ROCK SAMPLES

A total of 30 samples were selected from rock core drilled within the proposed Lamefoot stoping areas. Collar plots illustrating the location of the core holes selected for sampling are presented in Figure 2-9.

Within a given lithology, core samples were selected to represent the largest stratigraphic and spatial distribution possible. However, because of the configuration of the ore body, the majority of the core samples are biased spatially (and hence geochemically) toward the mineralized zone. Therefore, the sampling program developed for the selection of additional samples is not only consistent with the preliminary program but also ensures that the present program is adequately conservative.

Samples were **not composited** across drill holes or along wide elevation differences within the same hole in order to avoid obscuring trends with respect to acid generation potential. Samples were collected over an average elevation difference of approximately 6 feet within any given lithology. For the purposes of geochemical testing, this level of compositing provided representative, discrete, point samples of each rock type.

The number of samples chosen from a particular lithologic domain correlates directly to; (1) the potential for geochemical variability and acid generation potential (as defined through the preliminary testing) and to a lesser extent, (2) its estimated proportion of the total waste rock volume. The preliminary geochemical testing suggested that the large majority of the waste rock (79 percent) will be comprised of Group 3 materials with negligible potential for acid generation. Therefore, less emphasis was placed on correlating the number of samples to the waste or mine wall rock volume to avoid misdirecting the sampling program toward rock types which have negligible potential for acid generation. To provide a more conservative and potentially more effective waste characterization program, the focus of additional sample collection was directed toward identifying and characterizing the waste or mine wall rock lithologies with the highest potential for acid generation in an uncontrolled environment. Consequently, the number of samples collected for a given rock type does not correlate directly with its estimated proportion of the total volume.

Twenty clastic, three intrusive, three limestone and four low grade ore samples were submitted for acid base accounting analysis. Table 3-1 provides a summary of the samples submitted.

3.2 PHASE V - SECONDARY ACID BASE ACCOUNTING ANALYSIS

Clastic

Total sulfur values for the 20 clastic samples range from 2.02 to 8.29 percent with a geometric mean of 4.12, while the ANP values range from 9.6 to 109 $TCaCO_3/kT$ with a mean of approximately 60 $TCaCO_3/kT$. The resulting NNP values for the clastic samples range from -249.4 to 34.3 $TCaCO_3/kT$ with an average value of approximately -63 $TCaCO_3/kT$ suggesting that the clastic wall rock has a net acid generating potential.

TABLE 3-1

SUMMARY OF SAMPLES SUBMITTED FOR PHASE V ACID BASE ACCOUNTING ANALYSIS

Sample No.	Hole No.	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
1	C-170	Clastic	335-360	26100	7220	2840	Pulp	East	Clastics, trace silica, 1% pyrite
2	C-138	Clastic	500-510	26100	7385	3010	Pulp	East	Clastics, trace silica, trace $CaCO_3$, 0.5 % pyrite, trace chalcopyrite
3	C-166	Clastic	181-186	26300	7367	3060	Pulp	East	Clastics, trace pyrite as blebs and tiny veinlets, trace silica
4	C-142	Clastic	475-480	26300	7335	2978	Pulp	East	Clastics, 2% pyrite with trace chalcopyrite in tiny quartz veinlets
5	C-147	Clastic	275-280	26500	7200	2922	Pulp	East	Clastics, 2% pyrite as veinlets, 1% magnetite as blebs, trace hematite, weak silicic
6	C-178	Clastic	118-123	26500	7325	3080	Pulp	East	Clastics, 3% pyrite quartz-calcite veinlets, trace chalcopyrite, weak silicic
7	C-100	Clastic	263-268	26700	7185	2995	Pulp	East	Clastics, 20% pyrite with 5% magnetite in quartz veinlets, weak silicic, very chloritic
8	C-066	Clastic	311.5-316.5	26700	7244	2845	Pulp	East	Clastics, 1% pyrite with 0.5% chalcopyrite in quartz veinlets, moderately chloritic
9	C-105	Clastic	186-191	26900	7163	2965	Pulp	East	Clastics, 3% pyrite as patchy clots, trace chalcopyrite with quartz veinlets
10	C-086	Clastic	255-260	26900	7209	2794	Pulp	East	Clastics, 2% pyrite with <1% chalcopyrite with quartz as veinlets, trace $CaCO_3$
11	C-085	Clastic	181.5-185	26900	7165	2910	Pulp	East	Clastics, 2% pyrite with trace chalcopyrite in quartz veinlets, very chloritic
12	C-102	Clastic	78-83	26900	7245	3050	Pulp	East	Clastics, 15% pyrite with trace chalcopyrite as veins, slightly chloritic

TABLE 3-1
(Continued)

Sample No.	Hole No.	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
13	C-080	Clastic	90-95	27100	7135	2915	Pulp	East	Clastics, 3% pyrite with trace chalcopyrite in quartz veinlets
14	C-141	Clastic	345-350	27100	7160	2720	Pulp	East	Clastics, trace pyrite as tiny veinlets
15	C-184	Clastic	384-389	27100	7177	2618	Pulp	East	Clastics, trace pyrite as disseminations
16	C-095	Clastic	280-285	27300	7071	2550	Pulp	East	Clastics, <5% pyrite, in quartz veinlets
17	C-096	Clastic	359-365	27350	7017	2437	Pulp	East	Clastics, <5% pyrite in quartz veinlets, slightly silicic
18	C-116	Clastic	247-252	27300	7130	2660	Pulp	East	Clastics, 5% pyrite with 2% chalcopyrite in quartz veinlets
19	C-151	Clastic	194.5-200	27500	6981	2605	Pulp	East	Clastics, 10% pyrite with trace chalcopyrite in quartz veinlets
20	C-149	Clastic	255-260	27500	6922	2514	Pulp	East	Clastics, 2% pyrite with quartz in stockworks and disseminated, trace $CaCO_3$
21	C-191	Intrusive	363-370	26200	7148	2723	Core	West	Biotite rhyodacite, propyllitic altered, trace $CaCO_3$ as veinlets
22	C-140	Limestone	380-387.5	26200	7247	2940	Core	West	Limestone, $CaCO_3$ veining, bleached
23	C-178	Low Grade Ore	78-80	26500	7287	3087	Core	West	Altered limestone, 4% pyrite, 10% magnetitenetite, 1% pyrrhotite, 80% hematite, trace $CaCO_3$, slightly silicic
24	C-304	Intrusive	379-384	26400	7248	2790	Core	West	Hornblende, rhyodacite, trace pyrite disseminated
25	C-089	Intrusive	344-350	26700	7255	2768	Core	West	Hornblende, rhyodacite, no mineralization
26	C-066	Limestone	248-254	26700	7180	2855	Core	West	Limestone, 2% pyrite as wispy masses, 8% magnetite as patches, minor $CaCO_3$
27	C-110	Intrusive	324-328	26950	7171	2650	Core	West	Altered rhyodacite, argillic

TABLE 3-1
(Concluded)

Sample No.	Hole No.	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
28	C-160	Low Grade Ore	353-358	26950	7126	2767	Core	West	Altered limestone, trace pyrite disseminations, 50% magnetite, 35% hematite, trace $CaCO_3$, silicic
29	C-127	Low Grade Ore	239.5-244	27150	7065	2743	Core	West	Altered limestone, trace pyrite, 2% magnetite, 40% hematite, weakly silicic
30	C-131	Limestone	262-266.5	27350	7038	2546	Core	West	Limestone, bleached, trace pyrite disseminated

TABLE 3-2

ACID BASE ACCOUNTING RESULTS FOR PHASE V TESTING

Sample #	Sample Name	Sample Type	Total Sulfur (%)	AGP (TCaCO3/kT)	ANP (TCaCO3/kT)	NNP (TCaCO3/kT)	ANP:AGP RATIO
1	91-LFC-170	Clastic	2.02	63.1	55.2	-7.9	0.9
2	91-LFC-138	Clastic	3.65	114.1	11.6	-102.5	0.1
3	91-LFC-166	Clastic	5.45	170.3	67.5	-102.8	0.4
4	91-LFC-142	Clastic	2.1	65.6	28.8	-36.8	0.4
5	91-LFC-147	Clastic	4.31	134.7	109	-25.7	0.8
6	91-LFC-178	Clastic	6.88	215.0	47.2	-167.8	0.2
7	91-LFC-100	Clastic	8.11	253.4	28.6	-224.8	0.1
9	91-LFC-105	Clastic	2.5	78.1	74.6	-3.5	1.0
10	X1EB0103.011	Clastic	2.77	86.6	336	249.4	3.9
11	X1EB0102.018	Clastic	7.29	227.8	168	-59.8	0.7
12	91-LFC-102	Clastic	8.4	262.5	141	-121.5	0.5
13	XOEB0101.335	Clastic	2.21	69.1	63.6	-5.5	0.9
14	91-LFC-141	Clastic	5.64	176.3	22.2	-154.1	0.1
15	91-LFC-184	Clastic	2.95	92.2	52.9	-39.3	0.6
16	91-LFC-95	Clastic	5.21	162.8	88.7	-74.1	0.5
17	91-LFC-96	Clastic	2.55	79.7	114	34.3	1.4
18	91-LFC-116	Clastic	8.29	259.1	9.6	-249.5	0.0
19	91-LFC-151	Clastic	6.95	217.2	86.5	-130.7	0.4

TABLE 3-2
(Concluded)

Sample #	Sample Name	Sample Type	Total Sulfur (%)	AGP (TCaCO3/kT)	ANP (TCaCO3/kT)	NNP (TCaCO3/kT)	ANP:AGP RATIO
20	91-LFC-149	Clastic	3.25	101.6	77.1	-24.5	0.8
26	XOEB0102.348	Clastic	2.57	80.3	69.6	-10.7	0.9
	ARITHMETIC MEAN		4.66	145.47	82.59		0.74
	GEOMETRIC MEAN		4.12	128.87	60.00		0.47
21	91-LFC-191	Intrusive	0.15	4.7	227	222.3	48.3
22	91-LFC-140	Limestone	0.20	6.2	1020	1014	164.5
23	91-LFC-178	Low Grade Ore	4.17	130	429	299	3.3
24	91-LFC-304	Intrusive	1.20	37.5	252	194.5	6.2
25	91-LFC-089	Intrusive	0.12	3.8	308	304.2	81.0
26	91-LFC-066	Limestone	0.51	15.9	791	775.1	49.7
27	91-LFC-110	Intrusive	0.06	1.9	207	205.1	108.9
28	91-LFC-160	Low Grade Ore	0.21	6.6	596	589.4	90.3
29	91-LFC-127	Low Grade Ore	0.21	6.6	639	96.8	96.8
30	91-LFC-131	Limestone	0.13	4.1	1020	1015.9	248.7

Fourteen of the 20 samples have NNP values less than -20 $TCaCO_3/kT$ and are subsequently classified as Group 1 materials. Three samples are considered to have uncertain acid generation potential and are classified as Group 2 rocks, while two samples have a low to negligible potential for acid generation. Table 3-2 provides a summary of the acid base accounting results relative to the classification criteria. The ANP:AGP values are predominantly less than one and suggest that the majority of samples have acid generation potential.

The total sulfur content of the Phase V clastic samples appears to be higher than those samples submitted for Phase III testing. The mean total sulfur content of the initial clastic samples is 2.57 percent with a low value of 0.73 percent.

Limestone

Total sulfur values for the three limestone samples range from 0.13 to 0.51 percent and average 0.23 percent. ANP values range from 791 to 1020 $TCaCO_3/kT$ indicating that the limestone has vast neutralization capacity. Table 3-2 provides a summary of the acid base accounting results for the limestone samples. The most recent limestone samples are classified as Group 3 materials with NNP values an order of magnitude greater than 20 $TCaCO_3/kT$ and ANP:AGP values well in excess of 3.0. The most recent data suggest that there is little variation in sulfide content and more importantly the neutralization capacity appears to be consistent within the unit as well.

Low Grade Ore

Three low grade ore samples were submitted for acid base accounting consisting primarily of altered limestone. Total sulfur values range from 0.21 to 4.17 percent with a geometric mean of approximately 0.57 percent. ANP values range from 429 to 639 $TCaCO_3/kT$ suggesting that the low grade ore has a large acid neutralization potential. Table 3-2 presents the acid base accounting results for the low grade ore samples. Based on the Phase V results, the low grade ore samples are classified as Group 3 materials with NNP and ANP:AGP values ranging from 299 to 633 $TCaCO_3/kT$ and 3.3 to 96, respectively. These results are consistent with the preliminary Phase III results for the low grade ore unit.

Intrusive

Total sulfur values of the four intrusive samples submitted for acid base accounting range from 0.06 to 1.2 percent with ANP values ranging from 207 to 308 $TCaCO_3/kT$. As a result, the intrusive samples are classified as Group 3 materials with a low to negligible acid generation potential and significant acid neutralization potential. The propylitic alteration of the intrusive unit is most likely the source of the large amount of carbonate mineralization present in these samples. These results agree well with those generated during the initial characterization.

Phase V Conclusions

The results of Phase V testing indicate that the limestone, low grade ore and intrusive rock types have a negligible potential for acid generation and are classified as Group 3 material. The clastic samples submitted indicate that this rock type has a potential to generate acid with 70 percent of the samples classified as Group 1 materials. The total sulfur values of the Phase V clastic samples were higher than those collected during Phase III, indicating that sulfide contents within this unit vary spatially relative to proximity to the mineralized zone. The acid base accounting data for the limestone, low grade ore and intrusive units appear to agree well with the initial results, suggesting little variability within these rock types.

3.3 PHASE VI - IDENTIFICATION OF GEOCHEMICAL DOMAINS

Based on the Phase III acid base accounting results and information obtained from logging the core samples (Phase I), the lithological classification of the rock types was refined to reflect geochemical homogeneity and acid generation potential. As a result, four geochemical domains were identified;

- Limestone
- Low Grade Ore
- Clastic II
- Intrusive

These domains are believed to reflect, to the degree possible, the geochemical variability within the rock types present at Lamefoot which will comprise the waste material and wall rock. Based on the Phase V results the variability within each of the units is low. Hence, additional domains were not identified. The Clastic II designation was chosen for the clastic rock type primarily because of the degree of sulfide mineralization. This classification is consistent with the means of differentiating clastic domains at the Key Expansion.

3.4 PHASE VI CONCLUSIONS

Mine wall rock mineralogy and structural features control geochemical behavior relative to acid generation, acid neutralization, and leachability. The following physical rock features influence geochemical behavior:

- Nature, reactivity and surface area of sulfide grains (i.e., massive or disseminated);
- Fracture spacing and degree of mineralization;
- Particle size surface area exposure and/or exposure area as a function of frequency of water bearing fractures;
- Nature, reactivity and surface area of neutralizing minerals; and,
- The physical setting of the potentially reactive wall rock including availability of oxygen and water for reaction and transport.

The four Lamefoot Project waste rock domains have the following significant characteristics relative to acid generation potential:

- **Limestone:** This rock type is weakly to strongly fractured and generally contains 1 to 2 percent sulfide minerals located primarily along fractures and in veinlets. These structures may result in a preferential exposure of sulfide minerals as the waste rock is mined, however, the presence of significant amounts of calcium carbonate should neutralize any potential acid generation.
- **Low Grade Ore:** The low grade ore consists of altered limestone is comprised primarily of massive magnetite and/or sulfide with fragments of unaltered limestone incorporated into the matrix. The low grade ore is strongly fractured and subsequently healed with calcite. While preferential exposure of sulfides may occur the effective surface area of exposed carbonate minerals will also increase during mining. Significant amounts of pyrite and minor pyrrhotite are found within the low grade ore. Hematite and limonite are pervasive in zones of oxidation suggesting that weathering may have reduced the reactivity of the sulfide minerals. Cumulative sulfide, magnetite and oxides typically occur in amounts greater than 5 percent occasionally reaching amounts of 50 percent. The presence of

significant amounts of carbonate mineralization within this unit suggest that while oxidation of sulfide minerals may occur the solutions will be highly buffered.

- **Clastic:** The Clastic rock type contains sulfide percentages ranging from less than 1 percent to greater than 5 percent. The primary mode of occurrence is either as disseminations or within microfractures and veinlets. While veinlets often represent zones of weakness which can be preferentially fractured during mining, the sulfides disseminated within the rock mass will tend to remain relatively unexposed. If the Clastic rock becomes reactive it will be along fracture faces and not within the rock mass itself.

- **Intrusive:** This rock type generally contains only trace amounts of pyrite (0-1 percent). Generally, the pyrite is disseminated throughout the rock matrix as very fine grained poorly formed crystals. Although disseminated pyrite has a high surface area, and hence stronger reactivity, the total mass of pyrite exposed any given intrusive rock fragment face is generally far less than the total 1 percent. The actual percentage of total sulfur content that will be exposed and potentially reactive is likely to be insignificant. Pervasive propylitic alteration has resulted in significant amounts of calcite mineralization which occurs throughout the unit. Consequently, the intrusive unit is likely to provide neutralization capacity to the system.

In addition to mineralogy and rock structural features, the hydrogeological setting and configuration of the ultimate workings influence geochemical behavior. Groundwater flow through the unsaturated and saturated zones is controlled by the frequency and degree of interconnection of the fracture system. These characteristics exert significant control on the geochemical regime. Pyrite oxidation occurs both on the mine wall and on the fracture planes within the wall. If reactive pyrite is exposed on submerged fracture surfaces, the rate of oxidation is significantly reduced and may become negligible. As exposed pyrite oxidizes in the unsaturated fractures, the resulting acidity will either be flushed away periodically or will be retained.

3.5 PHASE VII - LITHOLOGIC AND GEOCHEMICAL CORRELATION WITH KEY EXPANSION

The purpose of Phase VII of the Lamefoot waste characterization program is to identify potential lithologic and geochemical similarity between the waste rock domains present at Lamefoot and their Key Project equivalents.

The geologic/lithologic similarity between the two sites, and the usefulness of ABA data to properly predict anticipated geochemical behavior of the various waste rock domains provide the focus for this portion of the Lamefoot waste characterization program. Much of the focus of the Lamefoot program is centered on establishing both the geologic/geochemical similarities and variabilities between the waste rock domains present at both sites in order to facilitate utilization of existing data and interpretations to direct the Lamefoot Project geochemical program and potential mitigative design.

3.5.1 Lithologic Correlation

Information gathered during the preliminary geologic investigation and the metallurgical/mineralogical studies were used to confirm the lithologic and mineralogic similarity between the waste rock lithologies at the Lamefoot and Key Expansion locations. In addition, the similarity (or differences) in those factors such as alteration, structure, mineralization, and carbonate occurrence which influence geochemical behavior was also established. Tables 3-3 and 3-4 present the lithologic descriptions and secondary features for the waste rock present at both the Lamefoot and Key Expansion Projects.

TABLE 3-3

SUMMARY OF WASTE ROCK LITHOLOGIES PRESENT AT THE KEY EXPANSION AND LAMEFOOT PROJECTS

Lithologic Unit	Geologic Description		Lithologic Similarities	Lithologic Differences
	Location			
	Key Project	Lamefoot Project		
Limestone	Dark gray to white, coarse grained to aphanitic, primarily composed of calcite with minor amounts of dolomite, massive with zones of extensive micro-fracturing. Dark gray portions commonly contain local zones of interbedded light gray to white limestone. Commonly sparitic with numerous styolites occurring throughout. Pyrite and pyhrrotite comprise the sulfide minerals and occur locally in fractures ranging from 0 to 1 percent. Magnetite occurs locally in fractures and disseminated within the matrix. The texture of the magnetite ranges from massive clots to fine grained. Magnetite abundance ranges from 0 to 15 percent.	Dark gray to light gray, with occasional interbedded layers of light colored limestone, coarse grained to aphanitic in texture, massive with zones of local fracturing. Abundant calcic styolites and veining. Pyrite and chalcopyrite with minor amounts of pyhrrotite comprise the sulfide minerals and occur locally in fractures and veinlets. Sulfide percentages range from 0 to 1 percent. Magnetite occurs within veins and veinlets and where mineralization is not limited to structure, the magnetite is occasionally disseminated throughout the matrix. Magnetite abundance ranges from 0 to 15 percent.	Primarily composed of calcite, interbedded zones of light and dark limestone, commonly sparitic with abundant styolites. Sulfides occur in fractures and veinlets in trace quantities, magnetite occurs in fractures, veinlets and disseminated in the matrix.	None

TABLE 3-3
(Continued)

Lithologic Unit	Geologic Description — Location — Key Project	Geologic Description — Location — Lamefoot Project	Lithologic Similarities	Lithologic Differences
Low Grade Ore	Bronze to black massive sulfide and/or magnetite. Sulfides consist of pyrite and phyrrotite. Low grade ore commonly is found as sulfide and magnetite horizons grading between one another. Textures range from fine grained to coarse grained. Sulfides occur in the magnetite as fine to medium clots, within veinlets and disseminated throughout the matrix. Magnetite occurrence in the massive sulfides is limited to fractures and crude bands. The low grade ore matrix is generally calcareous, weakly to strongly preserved. Hematite and limonite are common in the zones of oxidation.	Massive sulfide and/or magnetite, the magnetite consists of swirled bands of magnetite, hematite, and calcite with minor pyrite. Typically the magnetite contains fragments of unaltered limestone. Sulfides consist of massive to fine grained pyrite with variable amounts of magnetite. Pyrite occurrence in the massive magnetite is typically within stringers, veinlets, or disseminated throughout the matrix. Alteration of the low grade ore consists of chlorite and hematite with variable amounts of limonite. Calcite occurs within veins and disseminated through out the matrix.	Both low grade ores contain massive sulfides and magnetite. The matrix of the low grade ore is calcareous and weakly to strongly preserved. Hematite and limonite are common in oxidation zones.	Lamefoot contains fragments of unaltered limestone. Key massive sulfides contain more phyrrotite.
Intrusive	Pale green to gray, aphanitic to coarse grained, locally porphyritic, contains horneblende, biotite and variable amounts of plagioclase and potassium feldspar. Alteration consists of weak to strong chloritization. Fracturing ranges from moderate to strong and often calcite heals fractures. Sulfide abundance ranges from 0 to trace amounts (< 1%) and primarily occurs disseminated throughout the groundmass.	Pale olive to dark gray, aphanitic vitreous groundmass, containing biotite phenochrysts. Weak to strong propylitic and/or chloritic alteration, moderate to strong fracturing infilled with gouge or healed with calcite. Trace (<1%) amounts of pyrite typically occur disseminated throughout the groundmass.	Similar textures and composition. Both exhibit chloritic alteration. Similar structure with calcite healing fractures. Sulfide abundance is trace and occurs disseminated.	Lamefoot contains biotite phenocrysts. Alteration of Lamefoot includes propyllitic.

TABLE 3-3
(Concluded)

Lithologic Unit	Geologic Description		Lithologic Similarities	Lithologic Differences
	Location			
	Key Project	Lamefoot Project		
Clastic	Dark green to tan interbedded sharpstone conglomerate, siltstone, mudstone and cataclastite. Siltstones and mudstones are often interbedded as thin laminae. The siltstones exhibit well developed micro-fractures and shears and contain angular to subangular chert clasts. The conglomerate ranges from fine to coarse grained, containing subrounded to angular chert clasts supported in a siltstone matrix. Chloritic, silicic, and argillitic alteration ranges from weak to strong. In areas of pervasive alteration, bleaching of the unit is common. Pyrite occurs in micro-fractures and disseminated within quartz veins which are surrounded by bleached margins. Visual estimates of sulfide percentages range from trace to 2 percent, depending on the proximity to mineralization.	Light green to dark gray interbedded sharpstone conglomerate, siltstone, mudstone, and cataclastite. Moderate to strong fracturing occurs locally. Siltstone and mudstone have been altered locally to argillites with abundant quartz-pyrite veins. Pervasive alteration is chloritic with local strong hematitic alteration around fractures. Calcite often heals micro-fractures and shears. Bleached zones occur near areas of intense mineralization. Sulfides primarily occur within micro-fractures and disseminated throughout the matrix in zones of mineralization. Pyrite comprises the bulk of the sulfide mineralization and is generally fine grained to massive in texture. Sulfide abundance ranges from 0 to less than 10 percent.	Interbedded sharpstone conglomerate, siltstone, mudstone, and cataclastite. Pyrite composes the bulk of sulfide mineralization which occurs in micro-fractured quartz veins and disseminated throughout the matrix. Sulfide abundance is variable and is a function of proximity to the zone of mineralization.	Bleaching in areas of mineralization more common and distinct at Key. Alteration at Lamefoot is primarily chloritic while that at Key includes chloritic, silicic, and argillitic. Economic mineralization is significant at Lamefoot in areas adjacent to primary orebody, and these portions will be mined as ore.

TABLE 3-4

SUMMARY OF FACTORS INFLUENCING POTENTIAL GEOCHEMICAL BEHAVIOR OF WASTE/MINE WALL ROCK AT BOTH THE KEY EXPANSION AND LAMEFOOT PROJECTS

	Key Project				Lamefoot Project			
Lithologic Unit	Alteration	Structure	Sulfide Mineralization	Carbonate Occurrence	Alteration	Structure	Sulfide Mineralization	Carbonate Occurrence
Limestone	None or slightly dolomitized	Massive with moderate to strong fracturing and micro-fracturing.	Trace pyrite in micro-fractures and veinlets, occasionally disseminated.	Predominantly calcium carbonate with minor dolomitization.	None or slightly dolomitized	Massive with moderate to strong fracturing and micro-fracturing.	Trace pyrite in micro-fractures and veinlets, occasionally disseminated.	Predominantly calcium carbonate with minor dolomitization.
Low Grade Ore	Moderate to strong chlorite and calcite alteration.	Massive to broken, weakly to strongly fractured and micro-fractured.	Predominantly pyrite and phyrrotite occurring with massive and fine to coarse grained texture. Habit ranges from amorphous to euhedral depending on texture.	Calcite often occurs in the matrix especially in the massive magnetite. Also occurs in fractures and veins.	Calcic, hematitic, and limonitic alteration in zones of oxidation.	Massive to sheared, fractured and brecciated.	Predominantly pyrite and phyrrotite occurring with massive and fine to coarse grained texture. Habit ranges from amorphous to euhedral depending on texture.	Calcite often occurs in the matrix especially in the massive magnetite. Also occurs in fractures and veins.

TABLE 3-4
(Concluded)

Key Project					Lamefoot Project			
Lithologic Unit	Alteration	Structure	Sulfide Mineralization	Carbonate Occurrence	Alteration	Structure	Sulfide Mineralization	Carbonate Occurrence
Intrusive	Predominantly chloritic alteration.	Weakly to strongly sheared and fractured. Local zones of rubble in brecciated areas.	Trace amounts of pyrite disseminated in groundmass. Occurring as very fine to fine grained amorphous to sub-euhedral crystals.	Calcite occurs in veinlets typically associated with alteration.	Pervasive propyllitic and chloritic alteration.	Weakly to strongly sheared and fractured. Local zones of rubble in brecciated areas.	Trace amounts of pyrite disseminated in groundmass. Occurring as very fine to fine grained amorphous to sub-euhedral crystals.	Calcite occurs in veins typically associated with propyllitic alteration.
Clastic	Argillitic and chloritic alteration.	Weakly to strongly sheared and fractured. Local zones of rubble in brecciated areas. Calcite commonly heals fractures.	Weakly to strongly disseminated pyrite. Very fine to coarse grained amorphous to euhedral crystals. Sulfides occur in fractures, micro-fractures and in veinlets.	Calcite occurs disseminated throughout the matrix and within veinlets and micro-fractures.	Argillitic and chloritic alteration.	Weakly to strongly fractured and sheared. Local areas of rubble where brecciated. Calcite commonly heals fractures.	Weakly to strongly disseminated pyrite. Very fine to coarse grained amorphous to euhedral crystals. Sulfides occur in fractures, micro-fractures and in veinlets.	Calcite occurs disseminated throughout the matrix and within veinlets and micro-fractures.

The major lithologic characteristics between the rock types present at the Lamefoot and Key Expansion sites correlate very well with one another. The paragraphs which follow summarize the lithologic similarities between the units at both sites.

Limestone

The limestone at both Lamefoot and the Key Expansion is predominantly calcium carbonate with minor amounts of dolomite. Both contain interbedded layers of light colored limestone and abundant calcareous styolites and veining. Magnetite occurs in fractures, veinlets, and as disseminations throughout the matrix at both Lamefoot and the Key Expansion. Pyrite is the major sulfide mineral with minor pyrrhotite. Sulfide abundance in the limestone is similar at both sites with the mode of occurrence primarily limited to micro-fractures and veinlets.

Low Grade Ore

The low grade ore present at both sites consists of massive sulfides and magnetite. Pyrite, along with minor pyrrhotite and chalcopyrite comprise the sulfides present in the low grade ore at both Lamefoot and the Key Expansion sites. The magnetite consists of swirled bands of magnetite, hematite, and calcite. At both sites hematite and limonite are commonly found in the zones of oxidation. The habit and occurrence of the sulfides present in both the Key and Lamefoot low grade ore are similar as is the degree of carbonate mineralization. The matrix of the low grade ore at both sites is calcareous and preserved to varying degrees.

Clastic

The clastic rocks present at both sites are comprised of interbedded sharpstone conglomerates, siltstones, mudstones, and cataclastites. Strong to moderate fracturing and micro-fracturing are common within this unit at both Lamefoot and the Key Expansion. Pyrite composes the bulk of the sulfide mineralization which occurs in micro-fractures, quartz veins, and disseminated throughout the matrix. Sulfide abundance in the clastic units at both sites is spatially variable and is generally a function of proximity to the zone of mineralization. Clastic rocks at both sites exhibit two geochemical domains; Clastic I and Clastic II.

There are two primary differences between the clastic rocks which are present at the Lamefoot site and those at the Key Expansion site. The clastic rocks at the Key Expansion site which are located adjacent to the mineralized zones characteristically show distinct bleaching and carry no significant economic mineralization. The clastic rocks at the Lamefoot site which are similarly located exhibit variable degrees of bleaching and contain significant amounts of economic mineralization. The Clastic II rocks at Lamefoot typically contain higher sulfide percentages and increased carbonate mineralization. No Clastic I rocks will be exposed in the ultimate workings at Lamefoot and as such it is not considered as a geochemical domain within the mine. However, ABA data for the backfill samples suggest that these materials are classified as Clastic I.

Intrusive

The Tertiary intrusive is consistent between the two sites in texture, composition, sulfide abundance and mode of sulfide occurrence. The texture of the intrusive rocks present at Lamefoot and the Key Expansion ranges from aphanitic to coarse and is composed of hornblende, biotite and variable amounts of plagioclase and potassium feldspar. Sulfide abundance ranges from 0 to less than 1 percent and is generally disseminated throughout the groundmass or found within fractures and microfractures along with calcite.

Summary of Lithologic Correlation

Minor differences exist between rock types in secondary features such as alteration and structure, however, the differences do not effectively limit the ability to correlate units. The geologic environments of both the Lamefoot and Key Expansion ore deposits are virtually identical therefore, the waste and mine wall rock domains are also correlative. This geologic similarity allows the full range of geochemical data generated for the Key Expansion to augment the current Lamefoot waste characterization program. One of the objectives of the technical approach adopted for the Lamefoot waste rock characterization program focused establishing the degree of variability (both geochemical and geologic) between the Lamefoot and Key Project waste rock domains.

Extensive work was performed as part of the Key Expansion waste characterization program to ensure that the geochemical variability of the various waste rock domains was adequately defined. This process included both acid base accounting and kinetic testing. Preliminary predictions regarding potential acid generation were developed for each of the waste rock domains by evaluating their respective acid base accounts relative to criteria involving the acid neutralizing potential and the acid generation potential (see Appendix E, Golder 1992).

The validity of using ABA data to predict the acid generation potential of the various waste rock domains was subsequently confirmed through the kinetic testing completed as part of the Key Expansion waste characterization program. The results of the kinetic testing program illustrated that the criteria established to define acid generation potential, based on ABA data for the various waste rock domains, were representative of actual geochemical behavior and appropriately conservative.

3.5.2 Geochemical Correlation

In order to define the degree of geochemical similarity between the Key Expansion and Lamefoot sites the acid base accounting data were evaluated relative to each of the units. In addition, both the kinetic and leachability data from the Key Expansion waste characterization program are discussed relative to the acid generation and metal leachability potential of each of the units present at the Lamefoot site.

3.5.2.1 Acid Base Accounting

Limestone

The average total sulfur content of the Key Expansion limestone is 0.05 percent while the average for the limestone present at the Lamefoot site is approximately 0.4 percent. The acid neutralizing potential of the limestone at the two sites is similar with values of 871.3 and 786.1 $TCaCO_3/kT$ for Key and Lamefoot, respectively. As a result of these high neutralization potentials the NNP values for both sites are two orders of magnitude greater than 3, which is the criterion for negligible acid generation. Therefore, it can be concluded that these units are similar in their negligible potential for acid generation and provide the potential for neutralizing capability.

Low Grade Ore

The average total sulfur values for the low grade ore at the Key Expansion and Lamefoot sites are 4.81 and 0.13 percent, respectively. The acid neutralizing potential for the Key site is slightly lower with a value of 139 $TCaCO_3/kT$ as compared to 371 $TCaCO_3/kT$ for the low grade ore at Lamefoot. This suggests that the relative acid generation potential of the Key low grade ore is higher than present at the Lamefoot site. The difference in the low grade ore between the two sites is primarily in the degree of replacement in the limestone and the amount of unaltered parent material present. The low grade ore present at the Lamefoot site includes significant amounts of unaltered limestone clasts which increase its effective neutralization potential. Thus, it appears the low grade ore present at the Lamefoot site has a much lower potential for acid generation relative to its Key Expansion equivalent.

Clastic II

The Clastic II rock type has average total sulfur values of 1.02 and 3.81 percent at the Key Expansion and Lamefoot sites, respectively. The acid neutralizing potential of the Clastic II rocks at the Key site is 33.25 $TCaCO_3/kT$ as compared to 60.5 $TCaCO_3/kT$ at the Lamefoot site. Average net neutralization values suggest that the Key Clastic II rocks have an uncertain acid generation potential (-1.32 $TCaCO_3/kT$) while those at the Lamefoot site have a strong potential for acid generation (-58.5 $TCaCO_3/kT$). Comparison of the acid base accounting data for the Clastic II rocks at both sites suggest that the degree of mineralization within the Clastic II rocks found at the Lamefoot site is greater than that at the Key Expansion site. In addition, because of the mining method (i.e., open pit), the economic mineralization is much higher within the portions of the Clastic II rock at the Key site with similar sulfide contents to that of Lamefoot. Much of this portion of the unit was mined as ore, at the Key site and was not a significant portion of the waste rock volume. At Lamefoot the Clastic II rock will be left intact as wall rock in stopes.

Intrusive

Average total sulfur values for the intrusive rock at the Key and Lamefoot sites are 0.01 and 0.64, respectively. The intrusive rocks at both sites have significant acid neutralization potential ranging from 66.8 (Key) to 242 $TCaCO_3/kT$ (Lamefoot). The low total sulfur contents and the relatively high carbonate mineralization are common in the intrusive rocks present at both sites and is reflected in the high NNP values observed. Average NNP values for the Key and Lamefoot intrusive rocks are 171.6 and 220.0 $TCaCO_3/kT$, respectively. It is anticipated that the intrusive rocks present at the Key and Lamefoot sites are similar in their negligible potential for acid generation.

3.5.2.2 Kinetic Testing and EPA 1312 Leachability Testing

As part of the Key Expansion waste characterization program kinetic testing was completed on two Clastic I samples, two Clastic II samples, and one Low Grade Ore sample. The kinetic testing program and results are described in detail in both Golder 1992, and Golder 1993. The following sections discuss the results for the Key samples submitted for kinetic testing relative to their Lamefoot equivalents.

Kinetic Testing

Clastic I

Two Clastic I samples were submitted for kinetic testing and were run in humidity cells for a 20 week period. Initial pH values ranged from 7.44 to 7.55, while week 20 pH values ranged from 6.6 to 6.66. Alkalinity values remained stable throughout the 20 week testing period and ranged from 19 to 29 mg/l, suggesting that significant alkalinity depletion did not occur during this time. Sulfate production was low with concentrations below the detection limit (<10 mg/L) after the 20 week period. Cumulative sulfate production stabilized in both samples prior to the completion of the 20 week period indicating that oxidation of sulfide minerals ceased. In both samples cumulative alkalinity continued to increase at a rate greater than the sulfate production suggesting that the relative rates of reaction favored the dissolution of carbonate minerals. These samples were determined to be non-acid producing and it is anticipated that the behavior of the unmineralized Clastic I rocks at Lamefoot will be the same.

Clastic II

Two samples from the Clastic II domain were submitted for kinetic testing. The test duration differed for the two samples because uncertain geochemical behavior required that one sample be run for an additional 10 weeks to confirm the observed trends. Initial pH values ranged from 7.55 to 7.83 while final pH values ranged from 7.34 to 7.51. The relative stability of the pH values indicated that both samples were well buffered. Initial alkalinity values ranged from 28 to 36 mg/l and decreased to a common value of 19 mg/l at the end of testing. Cumulative alkalinity continued to increase through time suggesting that significant depletion of neutralization potential did not occur in either sample. Sulfate concentrations were low in both samples and at the end of testing were below the limits of detection. Cumulative sulfate production stabilized in both samples indicating that significant pyrite oxidation was not occurring. As a result, both samples were determined to be non-acid generating. The total sulfur values of these samples represent the low range of pyrite content for the Lamefoot Clastic II domain. As a result, it can be expected that while a portion of the Clastic II domain at Lamefoot may be classified as having a potential to generate acid based on ABA data its actual behavior will be non-acid generating.

Low Grade Ore

One Low Grade Ore sample was submitted for kinetic testing and was run for a 30 week period. The initial and final pH values for the Low Grade Ore were 7.38 and 7.18, respectively. Although there was some variation, no downward trends in pH were evident suggesting that the sample was well buffered. The initial alkalinity after one week was 24 mg/l. Subsequent to 30 weeks of testing the alkalinity decreased to 16 mg/l. Cumulative alkalinity continued to increase through time indicating that carbonate mineralization remained available for dissolution after 30 weeks of testing. Sulfate concentrations remained low throughout the duration of testing and after 30 were below detectable limits. Cumulative sulfate increased throughout the testing period until the final week when sulfate concentrations fell below detection. This suggests that pyrite oxidation was occurring but that the sample remained buffered because of the available neutralization capacity. This sample was designated as non-acid generating. Because this sample had a sulfur content higher than the average Lamefoot Low Grade Ore and a lower neutralization potential it is anticipated that the Lamefoot Low Grade Ore will exhibit the same non-acid generating behavior.

EPA 1312 Leachability Testing

The leachability characteristics of the five samples submitted for kinetic testing were defined using EPA Method 1312. The objective of this testing was to evaluate and classify the potential for significant metals leaching under acidic conditions. The complete discussion of results appears in Appendix E of Golder (1992).

All five of the samples tested produced leachates with moderately basic pH values which ranged from 8.26 to 8.92. Conductivity values ranged from 59 μmhos/cm to 77 μmhos/cm. Of the 26 metal species analyzed, 7 were above the detection limit in at least one sample. These species include aluminum (4 samples), barium (2 samples), calcium (5 samples), magnesium (5 samples), molybdenum (1 sample), strontium (5 samples), and zinc (1 sample). All species were present in trace amount with the exception of aluminum, calcium, and magnesium. Sulfate and iron were below detection limits in all five samples. The moderate pH values and low metals concentrations suggest that the Clastic and Low Grade Ore domains have low leachability characteristics. It is anticipated that given the general similarity in overall mineralogy of these units at both the Key and Lamefoot sites that the potential for significant leachability from the underground workings at Lamefoot is low.

3.5.2.3 Phase VII - Conclusions

The purpose of Phase VII of the Lamefoot waste characterization program is to identify potential lithologic and geochemical similarity between the waste rock domains present at Lamefoot and their Key Expansion equivalents.

A comparison of the acid base accounting data for both the Key Expansion and the Lamefoot sites suggest that while there is some variability, the Limestone and Intrusive domains reflect distinct similarities and as a result share a negligible potential for acid generation. While the Low Grade Ore domains differ between sites, the Lamefoot Low Grade Ore unit appears to have a low to negligible potential for acid generation. This is based on a comparison of both static and kinetic data. The Low Grade Ore sample submitted for kinetic testing from the Key site has a high potential to generate acid based on the static test data. This potential was not confirmed through the kinetic test data which indicated a well buffered system with low sulfate production and neutral pH values. Because the static test data for the Lamefoot low grade ore indicate a low potential for acid generation it is not anticipated that this rock type will be of environmental concern even in an uncontrolled setting.

The results of the Key Expansion kinetic testing program suggest that both the Clastic I and Low Grade Ore domains present at Lamefoot will be non-acid generating. The Clastic II domain appears to differ to a significant degree between the two sites indicating that a direct correlation may be difficult. Although the Clastic II samples tested from Key did not produce acid, extrapolating the results to the Lamefoot Clastic II unit may be inappropriate because of the differences in the degree of mineralization. As discussed in Section 3.5.2.1, total sulfur percentages for the Lamefoot Clastic II domain were slightly higher than those for the Key Expansion. As a result, the average NNP values for the Lamefoot Clastic II samples suggest that a strong potential exists for acid generation if the conditions in the mine are favorable for reaction and transport.

The following section discusses the controlling factors which influence both acid generation and contaminant transport in a fractured underground mine setting. In addition, the technical approach to evaluating the need for, and applicability of, various mitigative alternatives is also presented.

4.0 ACID DRAINAGE FROM MINE WALLS AND MITIGATIVE APPROACH

4.1 ACID DRAINAGE FROM MINE WALLS

A key factor in understanding the potential for acid drainage from mine walls is the knowledge of water movement in and near the mine walls. Sulfide oxidation only becomes an environmental concern when products such as hydronium ions, sulfate and metals are transported away from the reaction sites and into the local environment.

Two basic sources of water near the mine wall are groundwater and surface water, which may be interactive depending on the local hydrogeologic regime. Because of the limited connection between the ground surface and the deeper fractured bedrock aquifer, surface water is considered a negligible consideration at the Lamefoot site. In the site vicinity, deep groundwater migrates in fractures which are either saturated with water or partially unsaturated. The geochemical implications of partial or complete saturation are significant relative to potential environmental impacts. Some case studies have indicated that the reactivity of sulfide minerals becomes negligible under saturated conditions while a significant quantity of acidity can be stored in unsaturated portions of the mine walls (Morin 1990). This stored acidity can be available for transport to the receiving environment as a result of intermittent flushing or resaturation of the system.

Acid drainage and accelerated metal leaching are consequences of oxidation of sulfide minerals which results in an acidic environment around the sulfur-bearing metals. Water movement over the oxidation site mobilizes the acidity, sulfate and leached metals. The physical characteristics which constrain the movement of water in the system will ultimately control the potential for environmental impacts from sulfide oxidation. Therefore, the conceptual hydrogeologic model developed for the Lamefoot site (Section 1.3) has a primary role in evaluating the need and the potential effectiveness of various mitigative alternatives.

The following characteristics of the Lamefoot mine hydrogeology influence the potential for environmental impacts related to AMD:

- Frequency and degree of interconnection between water bearing fractures and joints;
- Rates and magnitude of groundwater inflow to the mine;
- Post-mining hydraulic equilibrium conditions and the resulting potential for mine outflow; and finally,
- Hydrologic connection of potentially acid generating unit(s) relative to the flow regime.

The following paragraphs discuss the Lamefoot mine hydrology relative to these characteristics.

The fracture and jointing characteristics controlling groundwater inflow into the mine relate primarily to igneous intrusions and the associated fractures in the country rocks. Nearly all the observed mine inflow originates from the contacts between the igneous intrusions and the surrounding limestone. Intrusive rocks are distributed throughout the limestone unit west of, and within the Anfo Fault. The occurrence of the intrusive rocks is structurally controlled by flat lying reverse thrust faults and steeply dipping normal faults. Localized intrusions typically result in fracturing of the adjacent country rock because of thermal and mechanical forces. Intrusion of the igneous bodies most likely enhanced the local permeability of these areas by increasing the degree of connection between existing fractures in the limestone. In addition, the relatively low permeability intrusions act as flow barriers which enhances the lateral migration of groundwater to the local, highly fractured margins adjacent to the intrusion. As a result, in areas within the Low Grade Ore for example, where flow has occurred in the recent past, iron staining is common. This staining reflects preferential flow patterns within the fracture/joint system and may indicate areas of unsaturation which are subject to intermittent flushing.

While the Clastic rocks contain intrusive bodies, they occur with much less frequency. Most significantly however is the lack of hydraulic control they exert on the occurrence and migration of water within this unit. Currently, no groundwater inflow has been observed either from the intrusive/clastic contacts or from fractures or joints within the Clastic. No iron staining has been observed on any of the Clastic exposures indicating that at no time in the recent past has water movement occurred along the walls.

Recent development drifting east of the Anfo Fault indicates that nearly all faults and joint sets observed in the Clastic rocks are healed with quartz mineralization or fine sericitic clay minerals. These healed faults effectively act as barriers to groundwater flow. In addition, the geometry and number of intersections of joints and faults present in the Clastic unit is significantly different than in the limestone, suggesting that a well developed, open fracture/joint system is not present within the Clastic rock greatly limiting the potential for transmitting groundwater. The primary permeability of the clastic rocks is extremely low because of low grade metamorphism which resulted in recrystallization of mineral grains and indicates that fracture flow rather than matrix flow will predominate, if at all.

The topographic location of the clastic rocks also influences its hydrostratigraphic significance. The clastic unit outcrops at a topographic high above the mine workings and as a result may be isolated from notable recharge. Effects of topography relative to the movement and occurrence of groundwater are typically related to the greater number and larger aperture size of fractures and more effective weathering in ravines than on upland areas. In contrast, the limestone unit outcrops along the side of the ridge and along the valley floor near Wolf Camp Road suggesting that recharge to this unit is potentially much more significant than to the Clastic unit. Limited recharge to this unit further reduces its potential for environmentally significant acid mine drainage.

These hydrogeologic characteristics influence the potential for AMD in the following ways:

- Flow into the mine is controlled entirely by the Limestone unit and Low Grade Ore indicating that the groundwater has significant amounts of alkalinity and buffering capacity;
- Flow into the mine from the Clastic rocks does not occur indicating that one of two primary agents for sulfide oxidation (i.e., oxygen and water) is not present and transport away from the reaction site is unlikely even if limited oxidation does occur;
- While the Clastic rock type has a potential for acid generation under the proper conditions, the lack of primary permeability and negligible secondary permeability (i.e., open fractures) effectively reduce the risk of acid generation from this unit to very low levels. Even if fracture flow was observed in the Clastic rock, the actual mass of reactive rock contributing to acid generation would be limited to the reaction halo adjacent to the fracture and as a result would be much lower than the total mass of potentially acid generating wall rock;
- Because of limited recharge to the Clastic rock, healed fractures and extremely low matrix porosity, the opportunity for potentially reactive sulfide minerals to come into contact with appreciable water is very low. Hence, transport of environmentally significant concentrations of potential contamination is not likely to occur.

4.2 DEVELOPMENT OF THE MITIGATIVE APPROACH

The mitigative approach currently being developed for the Lamefoot mine has two components; prevention and abatement methods. Prevention methods include designs incorporated into the mine plan which are developed with the acid generation potential of the wall rock in mind. Abatement methods include measures which can be implemented if the prevention design is not sufficiently effective. The following sections provide a discussion of each of these components.

4.2.1 Prevention of AMD

The control of AMD by preventing or inhibiting acid generation is the most efficient and environmentally sound level of control. The objective of acid generation control is to prevent or reduce the rate of acid formation at the source. The development of the Lamefoot mine will preserve to the degree possible, the natural hydrogeologic conditions which are favorable to preventing sulfide oxidation. As mentioned above, the Clastic unit possesses the greatest potential for acid generation. However this unit is also the least significant in terms of the hydrogeologic regime to the extent that groundwater is not transmitted through this unit into the mine.

Groundwater seepage into the mine will be minimized. By utilizing a mine design that reduces the potential for long-term subsidence and loss of hydraulic integrity within the Clastic unit. Echo Bay is committed to utilizing construction and mining methods which will result in conditions which will reduce or prevent AMD (Plan of Operations, Echo Bay 1993).

Additional site characteristics which will facilitate the prevention of AMD include highly alkaline groundwater which will inhibit acid generation. Because the groundwater seepage into the mine occurs entirely within the limestone and low grade ore the alkalinity values are on the order of 300 to 400 mg/l as

$CaCO_3$, with an average of approximately 330 mg/l as $CaCO_3$. This represents approximately 0.77 pounds of $CaCO_3$ for every 1000 liters of groundwater. Therefore significant insitu neutralizing capacity exists in the system which will contribute additional protection against the formation and migration of AMD.

In order to prevent disturbing potentially acid generating material in the area of the backfill excavation, additional drilling and sampling will be completed to define the areal extent of this rock. The excavation will be completed such that this material will be left in place to ensure to the degree possible that ARD formation does not occur.

4.2.2 Abatement of Acid Mine Drainage

As part of the mine design additional pH control will be affected by backfilling the mine workings with approximately 230,000 tons of limestone and low grade ore (i.e., altered limestone). The addition of excess alkaline material will provide further control in preventing the formation and/or migration of potential AMD into the receiving environment. If it is assumed that the Calcium Carbonate Effectiveness (CCE) of the limestone and low grade ore is on the order of 70 percent then the actual alkalinity available for pH control is approximately 161,000 tons $CaCO_3$. This represents approximately 1,400 pounds $CaCO_3$/ton limestone.

The combined reaction of acid generation from pyrite by air/water oxidation and subsequent reaction with calcite is described by the following equation:

$$4\ FeS2 + 8\ CaCO_3 + 15\ O_2 + 6\ H_2O \rightarrow 4\ Fe(OH)_3 + 8\ Ca^{+2} + 8\ CO_2$$

Effectively, it requires two moles of calcite to neutralize the acid generated by a single mole of pyrite. This is equivalent to 200 grams of calcite for 120 grams of pyrite on a mass basis. Therefore, the addition of 161,000 tons of $CaCO_3$ will neutralize the acidity generated by the oxidation of approximately 97,000 tons of pyrite. If it is assumed that the average pyrite content of the exposed Clastic unit is 4.12 percent then the amount of reactive rock required to generate enough acid to overwhelm the potential neutralizing capacity of the limestone backfill is approximately 2.3×10^6 tons.

Assuming an exposure area of approximately 466,700 ft^2 for the Clastic II domain in the ultimate mine workings and a bulk density of 140 lbs/ft^3, the thickness of the reactive halo around the exposed rock would be approximately 71 feet. Based on values cited in the literature, typical thicknesses for reaction halos along fracture surfaces are on the order of 20 cm (0.65 ft) (Morin 1990). This is a highly variable parameter however, which is controlled by the rate of water movement, the efficiency of product removal through flushing, potentially most importantly the primary permeability of the matrix material. If the rock is highly indurated such as the Clastic lithology, water and air will be limited to reacting with oxidation sites along the fracture face and not within the matrix of the rock (i.e., internal reaction). Because potential acid generation from the Clastic domain is most likely dominated by reactions on fracture surfaces the amount of reactive pyrite exposed to air and water is much less than is required to overwhelm the neutralization capacity of the limestone backfill.

The availability of excess neutralizing capacity combined with the apparent low percentage of reaction sites within the Clastic wall rock suggest that the net acid generation potential of the system is low under current conditions.

In summary, the objectives of the mitigative approach developed for the Lamefoot mine are as follows:

- Utilize the characteristics of the existing hydrogeologic regime to prevent or minimize acid generation;

- Minimize disturbance of the existing hydrogeologic conditions, especially relative to the Clastic hydrostratigraphic unit, by implementing construction and mining practices designed to preserve, to the degree possible, the existing conditions which are favorable to preventing acid mine drainage;
- Utilize limestone backfill to achieve additional acid generation control at the potential source in order to retard the rate of acid generation to an environmentally insignificant level;
- Utilize additional acid neutralizing backfill from surface;
- Implement selective excavation using visual and qualitative methods of estimating acid generation potential of the backfill during an ongoing monitoring program; and,
- Plug all openings to the mine workings with air/water tight cement seals.

5.0 REFERENCES

British Columbia Acid Mine Drainage Task Force. 1989. Draft Acid Rock Drainage Technical Guide, Volume 1.

Brodie, M.J., Broughton, L.M, and MacG, Dr. A. 1991. A Conceptual Rock Classification System for Waste Management and a Laboratory Methods for ARD Prediction from Rock Piles. Second International Conference on the Abatement of Acid Drainage, Montreal, Quebec, Canada.

Echo Bay Minerals. 1993. Lamefoot Plan of Operations, April 1993 Modification with Supplemental Information. July.

Farmer, Gene. 1992. A Conceptual Waste Rock Sampling Program for Mines Operating in Metallic Sulfide Bores with a Potential Acid Rock Drainage. Draft. U.S.D.A. Forest Service.

Golder. 1992. Final Environmental Impact Statement, Kettle River Key Project Expansion.

Golder. 1993.

Morin, K.A. 1990. Acid Drainage from Mine Walls the Main Zone Pit at Equity Silver Mines. British Columbia Acid Mine Drainage Task Force.

Sobek, A.A., W.A. Schuller, J.R. Freeman, and R.M. Smith. 1978. Field and Laboratory Methods Applicable to Overburden and Minesoils. United States Environmental Protection Agency, EPA 600/2-78-054.

Smith, A. 1992. Personal Communication. Telephone Conversation with Adrian Smith of ASCI, Inc. and John Chahbandour, Golder Associates Inc. Thursday, April 16.

APPENDIX B-2
MONITOR WELL DATA
APPROXIMATELY APRIL 1992 THROUGH NOVEMBER 1993
DATA PROVIDED BY ECHO BAY MINERALS, INC.

ALLUVIAL MONITOR WELL LF-1
MONTHLY REPORTS

| ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM |
| 11/22/93 Water Analysis Report 11:37 |
Page 1

Client : Echo Bay Minerals Company
Address : 921 Fish Hatchery Rd.
Republic, WA 99166
Attn. : Mr. W. Hunt
Project :
Sample ID: LF-1
Lab No. : 93-WI/11370
Sample Date Time: 11/02/93 13:15
Date Received: 11/05/93

Parameters		
Alkalinity as CaCO3	270.	mg/l
Bicarbonate as CaCO3	270	mg/l
Calcium, dissolved	119.	mg/l
Carbonate as CaCO3	0.	mg/l
Chloride	2.	mg/l
Conductivity @ 25C	782.	umhos/cm
Magnesium, dissolved	32.	mg/l
Nitrate as N, dissolved	0.70	mg/l
Nitrate/Nitrite as N	0.70	mg/l
Nitrite as N, dissolved	-0.01	mg/l
pH (lab)	8.1	units
Potassium, dissolved	3.	mg/l
Phosphorus, ortho diss	-0.005	mg/l
Sodium, dissolved	13.	mg/l
Sulfate	200.	mg/l
Cation-Anion Balance	-2.33	%
Solids, total dissolved	554.	mg/l
Solids, total suspended	8.	mg/l
Turbidity	1.94	ntu
Arsenic, dissolved	0.008	mg/l
Barium, dissolved	0.03	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l
Lead, dissolved	-0.02	mg/l
Manganese, dissolved	-0.01	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	-0.01	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	-0.001	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	-0.01	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager/SH.

Frank E. Polniak, Inorganic Laboratory Supervisor/

| ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM |
| 10/29/93 Water Analysis Report 12:23 |
==================================== Page 1 =========

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :
Sample Matrix:
Sample ID: LF1
Sample Date Time: 10/06/93 12:45

Lab No. : 93-WI/10440
Date Received: 10/08/93

Parameters

Alkalinity as CaCO3	282.	mg/l
Bicarbonate as CaCO3	282	mg/l
Carbonate as CaCO3	0.	mg/l
Calcium, dissolved	122.	mg/l
Chloride	3.	mg/l
Conductivity @ 25C	755.	umhos/cm
Cyanide, total	0.006	mg/l
pH (lab)	7.3	units
Hardness as CaCO3	432.	mg/l
Magnesium, dissolved	31.	mg/l
Nitrate as N, dissolved	0.77	mg/l
Nitrate/Nitrite as N	0.77	mg/l
Nitrite as N, dissolved	-0.01	mg/l
Potassium, dissolved	2.	mg/l
Phosphorus, ortho diss	-0.005	mg/l
Sodium, dissolved	10.	mg/l
Sulfate	177.	mg/l
Turbidity	6.	ntu
TDS Ratio (grav./calc.)	1.03	
Solids, total dissolved	526.	mg/l
Solids, total suspended	26.	mg/l
Cation-Anion Balance	-1.67	%
Arsenic, dissolved	0.007	mg/l
Barium, dissolved	0.03	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l
Lead, dissolved	-0.02	mg/l
Manganese, dissolved	-0.01	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	-0.01	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	-0.001	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	0.02	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager/

Frank E. Polniak, Inorganic Laboratory Supervisor/

| ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM |
| 10/29/93 Water Analysis Report 12:23 |

Page 1

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :
Sample Matrix:
Sample ID: LF1
Sample Date Time: 10/06/93 12:45

Lab No. : 93-WI/10440
Date Received: 10/08/93

Parameters

Alkalinity as CaCO3	282.	mg/l
Bicarbonate as CaCO3	282	mg/l
Carbonate as CaCO3	0.	mg/l
Calcium, dissolved	122.	mg/l
Chloride	3.	mg/l
Conductivity @ 25C	755.	umhos/cm
Cyanide, total	0.006	mg/l
pH (lab)	7.3	units
Hardness as CaCO3	432.	mg/l
Magnesium, dissolved	31.	mg/l
Nitrate as N, dissolved	0.77	mg/l
Nitrate/Nitrite as N	0.77	mg/l
Nitrite as N, dissolved	-0.01	mg/l
Potassium, dissolved	2.	mg/l
Phosphorus, ortho diss	-0.005	mg/l
Sodium, dissolved	10.	mg/l
Sulfate	177.	mg/l
Turbidity	6.	ntu
TDS Ratio (grav./calc.)	1.03	
Solids, total dissolved	526.	mg/l
Solids, total suspended	26.	mg/l
Cation-Anion Balance	-1.67	%
Arsenic, dissolved	0.007	mg/l
Barium, dissolved	0.03	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l
Lead, dissolved	-0.02	mg/l
Manganese, dissolved	-0.01	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	-0.01	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	-0.001	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	0.02	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager/SH

Frank E. Pelniak, Inorganic Laboratory Supervisor/

ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM
10/14/93 Water Analysis Report Page 1 of 2 16:54
Page 1

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :

Sample ID: LF-1
Sample Date Time: 09/14/93 12:15
Lab No. : 93-WI/09587
Date Received: 09/17/93

Parameters		
Alkalinity as CaCO3	264.	mg/l
Bicarbonate as CaCO3	264	mg/l
Calcium, dissolved	110.	mg/l
Chloride	2.	mg/l
Cyanide, total	0.008	mg/l
Hardness as CaCO3	394.	mg/l
Magnesium, dissolved	29.	mg/l
Nitrate as N, dissolved	.87	mg/l
Nitrate/Nitrite as N	0.88	mg/l
Nitrite as N, dissolved	0.01	mg/l
pH (lab)	8.1	units
Conductivity @ 25C	769.	umhos/cm
Potassium, dissolved	2.	mg/l
Sodium, dissolved	11.	mg/l
Sulfate	179.	mg/l
Cations (sum)	8.41	meq/l
Anions (sum)	9.09	meq/l
Cation-Anion Balance	-3.89	%
Solids, total dissolved	510.	mg/l
Solids, total suspended	160.	mg/l
Arsenic, dissolved	0.008	mg/l
Barium, dissolved	0.04	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l

Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager

Frank E. Polniak, Inorganic Laboratory Supervisor

ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM

10/14/93 Water Analysis Report Page 1 of 2 16:54

lient : Echo Bay Minerals, Inc.
ress : 921 Fish Hatchery Road
Republic, Washington 99166
ttn. : Accounts Payable cc: George Swank
Project :

ample ID: LF-1
ample Date Time: 09/14/93 12:15

Lab No. : 93-WI/09587
Date Received: 09/17/93

Parameters		
Alkalinity as CaCO3	264.	mg/l
Bicarbonate as CaCO3	264	mg/l
Calcium, dissolved	110.	mg/l
Chloride	2.	mg/l
Cyanide, total	0.008	mg/l
Hardness as CaCO3	394.	mg/l
Magnesium, dissolved	29.	mg/l
Nitrate as N, dissolved	.87	mg/l
Nitrate/Nitrite as N	0.88	mg/l
Nitrite as N, dissolved	0.01	mg/l
pH (lab)	8.1	units
Conductivity @ 25C	769.	umhos/cm
Potassium, dissolved	2.	mg/l
Sodium, dissolved	11.	mg/l
Sulfate	179.	mg/l
Cations (sum)	8.41	meq/l
Anions (sum)	9.09	meq/l
Cation-Anion Balance	-3.89	%
Solids, total dissolved	510.	mg/l
Solids, total suspended	160.	mg/l
Arsenic, dissolved	0.008	mg/l
Barium, dissolved	0.04	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l

ote: Negative sign "-" denotes that the value is less than "<"

cott Habermehl, Project Manager

rank E. Polniak, Inorganic Laboratory Supervisor

ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM
10/14/93 Water Analysis Report Page 2 of 2 17:00
Page 1

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :

Sample ID: LF-1
Sample Date Time: 09/14/93 12:15

Lab No. : 93-WI/09587
Date Received: 09/17/93

Parameters

Lead, dissolved	-0.02	mg/l
Manganese, dissolved	0.07	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	-0.01	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	-0.001	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	-0.01	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager

Frank E. Polniak, Inorganic Laboratory Supervisor

SVL ANALYTICAL, INC.
One Government Gulch ■ P.O. Box 929 ■ Kellogg, Idaho 83837-0929 ■ Phone: (208)784-1258 ■ Fax: (208)783-0891

SVL Job Number: 30907
SVL Sample ID#: W44213

Client: ECHO BAY
Collection Date: 8/05/93 1:15P
Date of Receipt: 08/09/93
Date of Report: 08/26/93

Sample: LF-1

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.64	units		E	Mercury-D	<0.0002	mg/L		
Alkalinity	261	mg/L		T	Molybdenum-D	<0.003	mg/L		P
Bicarbonate	261	mg/L		T	Nickel-D	<0.01	mg/L		P
WAD Cyanide	<0.01	mg/L		C	Potassium-D	3.1	mg/L		P
Aluminum-D	<0.01	mg/L		P	Selenium-D	<0.04	mg/L		P
Arsenic-D	<0.04	mg/L		P	Silver-D	<0.002	mg/L		P
Barium-D	0.030	mg/L		P	Sodium-D	12.5	mg/L		P
Boron-D	<0.01	mg/L		P	Zinc-D	<0.002	mg/L		P
Cadmium-D	<0.002	mg/L		P	Chloride	2.7	mg/L		I
Calcium-D	126	mg/L		P	Fluoride	0.2	mg/L		I
Chromium-D	<0.004	mg/L		P	Sulfate	181	mg/L		I
Copper-D	0.002	mg/L		P	NO3+NO2-N	0.86	mg/L		C
Iron-D	<0.02	mg/L		P	o-Phosphate	0.01	mg/L		I
Lead-D	<0.04	mg/L		P	TDS	553	mg/L		W
Magnesium-D	33.5	mg/L		P	TSS	63.0	mg/L		W
Manganese-D	<0.002	mg/L		P	Cyanide	<0.01	mg/L		C
					Conductivity	772	umhos		

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello by dc DATE 08/27/93
Joe Costello, Project Manager

SVL ANALYTICAL, INC.
One Government Gulch ■ P.O. Box 929 ■ Kellogg, Idaho 83837-0929 ■ Phone: (208)784-1258 ■ Fax: (208)783-0891

SVL Job Number: 30721
SVL Sample ID#: W42278

Client COC ID#:

Client: ECHO BAY
Collection Date: 7/07/93 1:45 PM
Date of Receipt: 07/12/93
Date of Report: 07/28/93

Sample: LF-1

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.57	units		W	Molybdenum-D	<0.003	mg/L		P
Alkalinity	255	mg/L		T	Nickel-D	<0.01	mg/L		P
Bicarbonate	255	mg/L		T	Potassium-D	2.2	mg/L		P
Cyanide	<0.01	mg/L		C	Selenium-D	<0.04	mg/L		P
Aluminum-D	<0.01	mg/L		P	Silver-D	<0.002	mg/L		P
Arsenic-D	<0.04	mg/L		P	Sodium-D	12.0	mg/L		P
Barium-D	0.030	mg/L		P	Zinc-D	<0.002	mg/L		P
Boron-D	<0.01	mg/L		P	Chloride	3.0	mg/L		I
Cadmium-D	<0.002	mg/L		P	Fluoride	0.4	mg/L		I
Calcium-D	127	mg/L		P	Sulfate	192	mg/L		I
Chromium-D	<0.004	mg/L		P	NO3+NO2-N	0.89	mg/L		C
Copper-D	<0.001	mg/L		P	o-Phosphate	<0.01	mg/L		I
Iron-D	<0.02	mg/L		P	Conductance	779	umhos		
Lead-D	<0.04	mg/L		P	TDS	547	mg/L		W
Magnesium-D	33.6	mg/L		P	TSS	34.2	mg/L		W
Manganese-D	<0.002	mg/L		P					
Mercury-D	<0.0002	mg/L		V					

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello by SR DATE 07/30/93
Joe Costello, Project Manager

SVL ANALYTICAL
Formerly Silver Valley Laboratories, Inc.

SVL Job Number: 30578
SVL Sample ID: W40994

Client: ECHO BAY
Collection Date: 06/08/93 12:45 PM
Date of Receipt: 06/11/93
Date of Report: 06/30/93

Sample: LF-1

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.98	units		W	Molybdenum-D	<0.008	mg/L		P
Alkalinity	246	mg/L		T	Nickel-D	<0.01	mg/L		P
Cyanide	<0.01	mg/L		C	Potassium-D	2.5	mg/L		P
Aluminum-D	<0.02	mg/L		P	Selenium-D	<0.04	mg/L		P
Arsenic-D	<0.04	mg/L		P	Silver-D	<0.002	mg/L		P
Barium-D	0.028	mg/L		P	Sodium-D	11.5	mg/L		P
Boron-D	<0.006	mg/L		P	Zinc-D	<0.001	mg/L		P
Cadmium-D	<0.002	mg/L		P	Chloride	2.9	mg/L		I
Calcium-D	122	mg/L		P	Fluoride	0.2	mg/L		I
Chromium-D	0.004	mg/L		P	Sulfate	188	mg/L		I
Copper-D	<0.004	mg/L		P	NO3+NO2-N	0.93	mg/L		C
Iron-D	<0.009	mg/L		P	o-Phosphate	0.14	mg/L		I
Lead-D	<0.04	mg/L		P	Conductance	800	umhos		
Magnesium-D	32.8	mg/L		P	TDS	531	mg/L		W
Manganese-D	<0.001	mg/L		P	TSS	186	mg/L		W
Mercury-D	<0.0002	mg/L		V					

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello / K Gray DATE 07/01/93

Joe Costello, Project Manager

SVL ANALYTICAL
Formerly Silver Valley Laboratories, Inc.

SVL Job Number: 30449
SVL Sample ID: W39861

Client: ECHO BAY
Collection Date: 05/11/93 11:45 AM
Date of Receipt: 05/14/93
Date of Report: 06/08/93

Sample: LF-1

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.72	units		W	Molybdenum-D	<0.008	mg/L		P
Alkalinity	240	mg/L		T	Nickel-D	<0.015	mg/L		P
Bicarbonate	240	mg/L		T	Potassium-D	2.6	mg/L		P
Cyanide	<0.01	mg/L		C	Selenium-D	<0.04	mg/L		P
Aluminum-D	<0.02	mg/L		P	Sodium-D	11.3	mg/L		P
Arsenic-D	<0.04	mg/L		P	Zinc-D	0.003	mg/L		P
Boron-D	<0.006	mg/L		P	Chloride	3.51	mg/L		I
Cadmium-D	0.002	mg/L		P	Fluoride	0.22	mg/L		I
Calcium-D	118	mg/L		P	Sulfate	181	mg/L		I
Copper-D	<0.004	mg/L		P	NO3+NO2-N	1.27	mg/L		C
Iron-D	<0.009	mg/L		P	o-Phosphate	0.06	mg/L		I
Lead-D	<0.04	mg/L		P	Conductance	765	umhos		
Magnesium-D	32.2	mg/L		P	TDS	455	mg/L		W
Manganese-D	<0.001	mg/L		P	TSS	58.6	mg/L		W
Mercury-D	<0.0002	mg/L		V	Silver-D	<0.002	mg/L		P
Barium-D	0.026	mg/L		P	Chromium-D	0.004	mg/L		P

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello / DATE 06/08/93
Joe Costello, Project Manager

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-1
Sample Collection Date: 4/06/93 NOON
Date of Sample Receipt: 04/09/93
Date of Report: 04/23/93

SVL Job Number: 30299
SVL Sample ID: W38807
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.90	units		W	Molybdenum-D	< .008	mg/L		P
Alkalinity	256.	mg/L		T	Nickel-D	< .01	mg/L		P
Bicarbonate	256.	mg/L		T	Potassium-D	2.6	mg/L		P
WAD Cyanide	< .01	mg/L		C	Selenium-D	.04	mg/L		P
Aluminum-D	.03	mg/L		P	Sodium-D	11.4	mg/L		P
Arsenic-D	< .04	mg/L		P	Zinc-D	.003	mg/L		P
Boron-D	< .006	mg/L		P	Chloride	2.02	mg/L		I
Cadmium-D	< .002	mg/L		P	Fluoride	.21	mg/L		I
Calcium-D	116.	mg/L		P	Sulfate	154.	mg/L		I
Copper-D	< .004	mg/L		P	NO3+NO2-N	1.28	mg/L		C
Iron-D	.018	mg/L		P	o-Phosphate	.07	mg/L		I
Lead-D	< .04	mg/L		P	Conductance	717.	umhos		
Magnesium-D	31.4	mg/L		P	TDS	474.	mg/L		W
Manganese-D	< .001	mg/L		P	TSS	111.	mg/L		W
Mercury-D	< .0002	mg/L		V					

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO T=TITRATION W=WET CHEM E=ELECTRODE

CONDUCTIVITY RESULT WAS ADJUSTED TO 25 DEGREES C

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 04/26/93

SVL ANALYTICAL

Client: ECHO BAY - WALT HUNT
Client Sample ID: LF-1
Sample Collection Date: 3/02/93 9:40
Date of Sample Receipt: 03/04/93
Date of Report: 03/16/93

SVL Job Number: 30163
SVL Sample ID: W37685
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.84	units		W	Molybdenum-D	< .007	mg/L		P
Alkalinity	270.	mg/L		T	Nickel-D	< .01	mg/L		P
Bicarbonate	270.	mg/L		T	Potassium-D	1.5	mg/L		P
WAD Cyanide	< .01	mg/L		C	Selenium-D	< .04	mg/L		P
Aluminum-D	< .03	mg/L		P	Sodium-D	11.6	mg/L		P
Arsenic-D	< .04	mg/L		P	Zinc-D	.015	mg/L		P
Boron-D	< .01	mg/L		P	Chloride	2.27	mg/L		I
Cadmium-D	< .002	mg/L		P	Fluoride	.26	mg/L		I
Calcium-D	130.	mg/L		P	Sulfate	204.	mg/L	20	I
Copper-D	< .003	mg/L		P	NO3+NO2-N	.93	mg/L		C
Iron-D	< .009	mg/L		P	o-Phosphate	.21	mg/L		I
Lead-D	< .03	mg/L		P	Conductance	810.	umhos		
Magnesium-D	35.5	mg/L		P	TDS	578.	mg/L		W
Manganese-D	< .002	mg/L		P	TSS	327.	mg/L		W
Mercury-D	< .0002	mg/L							

C/A BAL: 17.0 %diff CATION SUM: 10.0 meq/L ANION SUM: 7.1 meq/L

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO T=TITRATION W=WET CHEM E=ELECTRODE

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 03/16/93

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF1
Sample Collection Date: 2/03/93 10:45A
Date of Sample Receipt: 02/03/93
Date of Report: 02/19/93

SVL Job Number: 30094
SVL Sample ID: W36830

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.80	units			Mercury-D	< .0002	mg/L		V
Alkalinity	271.	mg/L			Molybdenum-D	< .007	mg/L		P
Bicarbonate	271.	mg/L			Nickel-D	< .01	mg/L		P
WAD Cyanide	< .01	mg/L		C	Potassium-D	2.2	mg/L		P
Aluminum-D	< .03	mg/L		P	Selenium-D	< .04	mg/L		P
Arsenic-D	< .04	mg/L		P	Sodium-D	11.5	mg/L		P
Boron-D	< .01	mg/L		P	Zinc-D	.021	mg/L		P
Cadmium-D	< .002	mg/L		P	Chloride	3.23	mg/L		I
Calcium-D	140.	mg/L		P	Fluoride	.20	mg/L		I
Copper-D	< .003	mg/L		P	Sulfate	221.	mg/L		I
Iron-D	< .009	mg/L		P	NO3+NO2-N	.58	mg/L		C
Lead-D	< .03	mg/L		P	Conductance	851.	umhos		
Magnesium-D	37.8	mg/L		P	TDS	619.	mg/L		
Manganese-D	< .002	mg/L		P	TSS	357.	mg/L		
Ortho-Phosphate	<.01	mg/L			Silver-D	< .005	mg/L		P
Barium-D	.03	mg/L		P	Chromium-D	< .006	mg/L		P

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 02/19/93

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-1
Sample Collection Date: 1/05/93 10:45
Date of Sample Receipt: 01/13/93
Date of Report: 01/25/93

SVL Job Number: 30029
SVL Sample ID: W36252
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	8.00	units			Potassium-D	2.7	mg/L		P
Alkalinity	282.	mg/L			Selenium-D	< .04	mg/L		P
Bicarbonate	282.	mg/L			Sodium-D	11.1	mg/L		P
WAD Cyanide	< .01	mg/L		C	Zinc-D	.009	mg/L		P
Aluminum-D	.11	mg/L		P	Chloride	2.98	mg/L		I
Arsenic-D	.04	mg/L		P	Fluoride	.25	mg/L		I
Boron-D	.01	mg/L		P	Sulfate	218.	mg/L		I
Cadmium-D	< .002	mg/L		P	NO3+NO2-N	1.99	mg/L		C
Calcium-D	137.	mg/L		P	o-Phosphate	1.02	mg/L		I
Copper-D	.004	mg/L		P	Conductance	862.	umhos		
Iron-D	.124	mg/L		P	TDS	571.	mg/L		
Lead-D	.08	mg/L		P	TSS	453.	mg/L		
Magnesium-D	35.6	mg/L		P	Cyanide	< .01	mg/L		C
Manganese-D	< .002	mg/L		P	Barium-D	.031	mg/L		P
Mercury-D	< .0002	mg/L		V	Chromium-D	< .006	mg/L		P
Molybdenum-	< .007	mg/L		P	Silver-D	< .004	mg/L		P
Nickel-D	< .01	mg/L		P					

C/A BAL: 15.2 %diff CATION SUM: 10.3 meq/L ANION SUM: 7.6 meq/L

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 01/25/93

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-1
Sample Collection Date: 12/02/92 12:15 PM
Date of Sample Receipt: 12/07/92
Date of Report: 12/21/92

SVL Job Number: 21571
SVL Sample ID: W35183
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	8.07	units			Molybdenum-D	< .008	mg/L		P
Alkalinity	281.	mg/L			Nickel-D	< .005	mg/L		P
Bicarbonate	278.	mg/L			Potassium-D	2.8	mg/L		P
WAD Cyanide	< .01	mg/L		C	Selenium-D	< .06	mg/L		P
Aluminum-D	.05	mg/L		P	Silver-D	< .004	mg/L		P
Arsenic-D	< .05	mg/L		P	Sodium-D	13.5	mg/L		P
Barium-D	.035	mg/L		P	Zinc-D	.003	mg/L		P
Boron-D	< .005	mg/L		P	Chloride	2.6	mg/L		I
Cadmium-D	< .004	mg/L		P	Fluoride	.3	mg/L		I
Calcium-D	145.	mg/L		P	Sulfate	226.	mg/L		I
Chromium-D	< .003	mg/L		P	NO3+NO2-N	.69	mg/L		C
Copper-D	< .004	mg/L		P	o-Phosphate	.60	mg/L		I
Iron-D	.056	mg/L		P	Conductance	897.	mg/L		
Lead-D	< .05	mg/L		P	TDS	572.	mg/L		
Magnesium-D	37.4	mg/L		P	TSS	310.	mg/L		
Manganese-D	.006	mg/L		P	Oil & Grease	<1.0	mg/L		
Mercury-D	< .0002	mg/L							

M(ethod): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 12/22/92

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-1
Sample Collection Date: 11/10/92 11:30AM
Date of Sample Receipt: 11/16/92
Date of Report: 12/02/92

SVL Job Number: 21503
SVL Sample ID: W34649
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.80	units			Molybdenum-D	< .007	mg/L		P
Alkalinity	266.	mg/L			Nickel-D	< .02	mg/L		P
Bicarbonate	266.	mg/L			Potassium-D	3.16	mg/L		P
WAD Cyanide	< .01	mg/L		C	Selenium-D	< .040	mg/L		P
Aluminum-D	.60	mg/L		P	Silver-D	.003	mg/L		P
Arsenic-D	< .04	mg/L		P	Sodium-D	11.61	mg/L		P
Barium-D	.042	mg/L		P	Zinc-D	.014	mg/L		P
Boron-D	< .06	mg/L		P	Chloride	2.8	mg/L		I
Cadmium-D	< .002	mg/L		P	Fluoride	.3	mg/L		I
Calcium-D	140.40	mg/L		P	Sulfate	224.0	mg/L		I
Chromium-D	< .003	mg/L		P	NO3+NO2-N	.66	mg/L		C
Copper-D	.005	mg/L		P	o-Phosphate	4.63	mg/L		
Iron-D	.584	mg/L		P	Conductance	826.	umhos		
Lead-D	.10	mg/L		P	TDS	629.	mg/L		
Magnesium-D	37.22	mg/L		P	TSS	1737.3	mg/L		
Manganese-D	.027	mg/L		P	Oil & Grease	--NA--			
Mercury-D	< .0002	mg/L		V					

M(ethod): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY
--NA-- : NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

M. Bencich by SH DATE 12/02/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-1
Sample Collection Date: 10/14/92 10:30AM
Date of Sample Receipt: 10/19/92
Date of Report: 11/16/92 REVISED

SVL Job Number: 21387
SVL Sample ID: W33388
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	ANALYTE	RESULT	UNIT	DILN
Silver	< .004	mg/L		Selenium	< .062	mg/L	
Aluminum	10.3	mg/L		Zinc	.130	mg/L	
Arsenic	.065	mg/L		Mercury	< .0002	mg/L	
Boron	.042	mg/L		Chloride	2.54	mg/L	
Barium	.204	mg/L		Fluoride	.28	mg/L	
Calcium	145.1	mg/L		Sulfate	218.3	mg/L	
Cadmium	< .004	mg/L		Alkalinity	274.	mg/L	
Chromium	.023	mg/L		Conductance	865.	mg/L	
Copper	.076	mg/L		TDS	610.	mg/L	
Iron	22.8	mg/L		TSS	434.7	mg/L	
Potassium	4.39	mg/L		Oil & Grease	--NA--		
Magnesium	41.5	mg/L		o-Phosphate	.10	mg/L	
Manganese	.458	mg/L		Bicarbonate	274.	mg/L	
Molybdenum	.008	mg/L		pH	8.0	units	
Sodium	11.5	mg/L		NO3+NO2-N	.66	mg/L	
Nickel	.035	mg/L		WAD Cyanide	< .01	mg/L	
Lead	< .049	mg/L					

--NA-- NOT ANALYZED

DISSOLVED METALS

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 11/16/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-1
Sample Collection Date: 07/08/92 12:30 PM
Date of Sample Receipt: 07/14/92
Date of Report: 7/28/92

SVL Job Number: 20797
SVL Sample ID: W27177
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN
pH	8.08	units	
Alkalinity	246.	mg/L	
Bicarbonate	246.	mg/L	
WAD Cyanide	< .01	mg/L	
Aluminum-D	.08	mg/L	
Arsenic-D	< .002	mg/L	
Barium-D	.035	mg/L	
Boron-D	< .02	mg/L	
Cadmium-D	< .003	mg/L	
Calcium-D	127.30	mg/L	
Chromium-D	< .005	mg/L	
Copper-D	.056	mg/L	
Iron-D	.12	mg/L	
Lead-D	< .001	mg/L	
Magnesium-D	32.56	mg/L	
Manganese-D	.007	mg/L	
Mercury-D	< .0002	mg/L	

ANALYTE	RESULT	UNIT	DILN
Molybdenum-D	< .02	mg/L	
Nickel-D	< .02	mg/L	
Potassium-D	3.	mg/L	
Selenium-D	< .002	mg/L	
Silver-D	< .006	mg/L	
Sodium-D	9.71	mg/L	
Zinc-D	.016	mg/L	
Chloride	3.2	mg/L	
Fluoride	.3	mg/L	
Sulfate	189.0	mg/L	
NO3+NO2-N	.74	mg/L	
o-Phosphate	< .01	mg/L	
Conductance	793.	umhos	
TDS	521.	mg/L	
TSS	53.0	mg/L	
Oil & Grease	--NA--		

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

M. Bencich. by SH DATE 07/29/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-1
Sample Collection Date: 06/09/92 10:30AM
Date of Sample Receipt: 06/15/92
Date of Report: 6/30/92

SVL Job Number: 20666
SVL Sample ID: W25738
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN
pH	7.76	units	
Alkalinity	234.	mg/L	
Bicarbonate	234.	mg/L	
WAD Cyanide	< .01	mg/L	
Aluminum-D	.91	mg/L	
Arsenic-D	< .04	mg/L	
Barium-D	.044	mg/L	
Boron-D	< .02	mg/L	
Cadmium-D	.003	mg/L	
Calcium-D	126.10	mg/L	
Chromium-D	< .005	mg/L	
Copper-D	.006	mg/L	
Iron-D	1.48	mg/L	
Lead-D	< .04	mg/L	
Magnesium-D	34.36	mg/L	
Manganese-D	.028	mg/L	

ANALYTE	RESULT	UNIT	DILN
Mercury-D	< .0002	mg/L	
Molybdenum-D	< .02	mg/L	
Nickel-D	< .02	mg/L	
Potassium-D	2.	mg/L	
Selenium-D	< .05	mg/L	
Silver-D	< .006	mg/L	
Sodium-D	9.54	mg/L	
Zinc-D	.021	mg/L	
Chloride	2.7	mg/L	
Fluoride	.3	mg/L	
Sulfate	211.0	mg/L	20X
NO3+NO2-N	.87	mg/L	
o-Phosphate	.69	mg/L	
Conductance	798.	umhos	
TDS	616.	mg/L	
TSS	292.5	mg/L	
Cyanide	< .01	mg/L	

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

M. Bencich by SH DATE 06/30/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-1
Sample Collection Date: 05/05/92 9:00AM
Date of Sample Receipt: 05/07/92
Date of Report: 5/19/92

SVL Job Number: 20489
SVL Sample ID: W24376
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN
pH	8.02	units	
Alkalinity	247.	mg/L	
Bicarbonate	247.	mg/L	
WAD Cyanide	< .01	mg/L	
Aluminum-D	.07	mg/L	
Arsenic-D	.047	mg/L	
Barium-D	--NA--		
Boron-D	< .02	mg/L	
Cadmium-D	< .003	mg/L	
Calcium-D	135.60	mg/L	
Chromium-D	--NA--		
Copper-D	< .005	mg/L	
Iron-D	.09	mg/L	
Lead-D	.019	mg/L	
Magnesium-D	35.00	mg/L	
Manganese-D	.004	mg/L	
Mercury-D	< .0002	mg/L	
Molybdenum-D	< .02	mg/L	
Nickel-D	< .02	mg/L	
Potassium-D	3.	mg/L	
Selenium-D	< .002	mg/L	
Silver-D	--NA--		
Sodium-D	9.16	mg/L	
Zinc-D	< .005	mg/L	
Chloride	2.2	mg/L	
Fluoride	.3	mg/L	
Sulfate	214.0	mg/L	
NO3+NO2-N	.99	mg/L	
o-Phosphate	< .05	mg/L	
Conductance	769.	umhos	
TDS	544.	mg/L	
TSS	50.9	mg/L	

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

Melba Bercich by Bl DATE 05/20/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-1
Sample Collection Date: 04/07/92
Date of Sample Receipt: 04/14/92
Date of Report: 5/ 1/92

SVL Job Number: 20387
SVL Sample ID: W23621
Time: 1:30 PM
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN
pH	7.72	units	
Alkalinity	254.	mg/L	
Bicarbonate	254.	mg/L	
WAD Cyanide	< .01	mg/L	
Aluminum-D	< .04	mg/L	
Arsenic-D	.026	mg/L	
Boron-D	< .02	mg/L	
Cadmium-D	< .003	mg/L	
Calcium-D	128.10	mg/L	
Copper-D	< .005	mg/L	
Iron-D	.04	mg/L	
Lead-D	< .001	mg/L	
Magnesium-D	34.25	mg/L	
Manganese-D	< .001	mg/L	
Mercury-D	< .0002	mg/L	
Molybdenum-D	< .02	mg/L	
Nickel-D	< .02	mg/L	
Potassium-D	2.	mg/L	
Selenium-D	.012	mg/L	
Sodium-D	9.66	mg/L	
Zinc-D	.006	mg/L	
Chloride	1.9	mg/L	
Fluoride	.3	mg/L	
Sulfate	203.0	mg/L	
NO3+NO2-N	.59	mg/L	
o-Phosphate	1.14	mg/L	
Conductance	806.	umhos	
TDS	552.	mg/L	
TSS	863.0	mg/L	
Oil & Grease	--NA--		

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

M. Bencich by SH DATE 05/04/92

ECHO BAY MINERALS - KETTLE RIVER OPERATION
MONTHLY GROUNDWATER DATA

STATION	DATE	TIME	WELL TD	DEPTH TO WATER	pH	TEMP. (C)	CONDUCTIVITY (umho)	Comments
LF1	10/18/92	1:10p	25.0		7.5	5	887	
LF1	04/07/92	1:30p	25.0	9.9	7.9	5	921	
LF1	05/05/92	9:00a	25.0	9.3	7.8	5	906	
LF1	06/09/92	10:30a	25.0	9.9	7.7	6	892	
LF1	07/08/92	12:15p	25.0	10.0	7.8	6	902	
LF1	08/05/92	12:00p	25.0					No Access
LF1	09/08/92	10:00a	25.0					No Access
LF1	10/14/92	10:30a	25.0	10.2	7.7	5	910	
LF1	11/10/92	11:30a	25.0	10.6	7.8	4	906	
LF1	12/02/92	12:15p	25.0	10.2	7.8	4	946	
LF1	01/05/93	10:45a	25.0	10.2	7.3	4	902	
LF2	10/18/91	11:45a	36.0	7.2	7.3	5	986	
LF2	04/07/92	2:00p	36.0	13.0	7.8	5	1170	
LF2	05/05/92	8:45a	36.0	13.8	7.7	5	1100	
LF2	06/09/92	10:15a	36.0	16.0	7.4	8	1040	
LF2	07/08/92	12:15p	36.0	16.4	7.5	6	1110	
LF2	08/05/92	12:00p	36.0	19.1	7.6	8	1096	
LF2	09/08/92	10:00a	36.0	22.2	7.5	7	1020	
LF2	10/14/92	10:45a	36.0	25.0	7.6	5	1000	
LF2	11/10/92	11:15p	36.0	27.8	7.7	5	1040	
LF2	12/02/92	12:00a	36.0	27.6	7.5	5	1100	
LF2	01/05/93	11:00a	36.0	29.0	7.3	4	1105	

ALLUVIAL MONITOR WELL LF-2
MONTHLY REPORTS

ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM
11/22/93 Water Analysis Report 11:38
Page 1

Client : Echo Bay Minerals Company
Address : 921 Fish Hatchery Rd.
Republic, WA 99166
Attn. : Mr. W. Hunt
Project :
Sample ID: LF-2 Lab No. : 93-WI/11371
Sample Date Time: 11/02/93 13:00 Date Received: 11/05/93

Parameters		
Alkalinity as CaCO3	296.	mg/l
Bicarbonate as CaCO3	296	mg/l
Calcium, dissolved	150.	mg/l
Carbonate as CaCO3	0.	mg/l
Chloride	3.	mg/l
Conductivity @ 25C	968.	umhos/cm
Magnesium, dissolved	41.	mg/l
Nitrate as N, dissolved	1.01	mg/l
Nitrate/Nitrite as N	1.01	mg/l
Nitrite as N, dissolved	-0.01	mg/l
pH (lab)	8.0	units
Potassium, dissolved	3.	mg/l
Phosphorus, ortho diss	-0.005	mg/l
Sodium, dissolved	13.	mg/l
Sulfate	278.	mg/l
Cation-Anion Balance	-1.41	%
Solids, total dissolved	710.	mg/l
Solids, total suspended	-2.	mg/l
Turbidity	0.20	ntu
Arsenic, dissolved	0.005	mg/l
Barium, dissolved	0.03	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l
Lead, dissolved	-0.02	mg/l
Manganese, dissolved	-0.01	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	-0.01	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	-0.001	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	-0.01	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager/S.H.

Frank E. Polniak, Inorganic Laboratory Supervisor/

| ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM |
| 10/29/93 Water Analysis Report 12:24 |
== Page 1 ========

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :
Sample Matrix:
Sample ID: LF2 Lab No. : 93-WI/10441
Sample Date Time: 10/06/93 12:30 Date Received: 10/08/93

Parameters

Alkalinity as CaCO3	302.	mg/l
Bicarbonate as CaCO3	302	mg/l
Carbonate as CaCO3	0.	mg/l
Calcium, dissolved	150.	mg/l
Chloride	3.	mg/l
Conductivity @ 25C	877.	umhos/cm
Cyanide, total	0.006	mg/l
pH (lab)	7.6	units
Hardness as CaCO3	539.	mg/l
Magnesium, dissolved	40.	mg/l
Nitrate as N, dissolved	1.01	mg/l
Nitrate/Nitrite as N	1.01	mg/l
Nitrite as N, dissolved	-0.01	mg/l
Potassium, dissolved	3.	mg/l
Phosphorus, ortho diss	-0.005	mg/l
Sodium, dissolved	11.	mg/l
Sulfate	263.	mg/l
Turbidity	0.47	ntu
TDS Ratio (grav./calc.)	1.03	
Solids, total dissolved	666.	mg/l
Solids, total suspended	-2.	mg/l
Cation-Anion Balance	-1.35	%
Arsenic, dissolved	0.005	mg/l
Barium, dissolved	0.03	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l
Lead, dissolved	-0.02	mg/l
Manganese, dissolved	-0.01	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	-0.01	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	-0.001	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	-0.01	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager/SH.

Frank E. Polniak, Inorganic Laboratory Supervisor/

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :

Sample ID: LF-2
Sample Date Time: 09/14/93 12:00

Lab No. : 93-WI/09588
Date Received: 09/17/93

Parameters

Alkalinity as CaCO3	240.	mg/l
Bicarbonate as CaCO3	240	mg/l
Calcium, dissolved	137.	mg/l
Chloride	2.	mg/l
Cyanide, total	0.003	mg/l
Hardness as CaCO3	494.	mg/l
Magnesium, dissolved	37.	mg/l
Nitrate as N, dissolved	0.81	mg/l
Nitrate/Nitrite as N	0.81	mg/l
Nitrite as N, dissolved	-0.01	mg/l
pH (lab)	8.1	units
Conductivity @ 25C	822.	umhos/cm
Potassium, dissolved	3.	mg/l
Sodium, dissolved	12.	mg/l
Sulfate	290.	mg/l
Cations (sum)	10.49	meq/l
Anions (sum)	10.95	meq/l
Cation-Anion Balance	-2.15	%
Solids, total dissolved	616.	mg/l
Solids, total suspended	780.	mg/l
Arsenic, dissolved	0.006	mg/l
Barium, dissolved	0.04	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	0.01	mg/l

Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager

Frank E. Polniak, Inorganic Laboratory Supervisor

ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM
10/14/93 Water Analysis Report Page 2 of 2 17:00

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :

Sample ID: LF-2 Lab No. : 93-WI/09588
Sample Date Time: 09/14/93 12:00 Date Received: 09/17/93

Parameters		
Lead, dissolved	-0.02	mg/l
Manganese, dissolved	0.05	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	-0.01	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	-0.001	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	-0.01	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager /TH for SH

Frank E. Polniak, Inorganic Laboratory Supervisor

SVL ANALYTICAL, INC.

One Government Gulch ■ P.O. Box 929 ■ Kellogg, Idaho 83837-0929 ■ Phone: (208)784-1258 ■ Fax: (208)783-0891

SVL Job Number: 30907
SVL Sample ID#: W44214

Client: ECHO BAY
Collection Date: 8/05/93 1:00P
Date of Receipt: 08/09/93
Date of Report: 08/26/93

Sample: LF-2

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.19	units		E	Mercury-D	0.0002	mg/L		V
Alkalinity	274	mg/L		T	Molybdenum-D	<0.003	mg/L		P
Bicarbonate	274	mg/L		T	Nickel-D	<0.01	mg/L		P
Aluminum-D	<0.01	mg/L		P	Potassium-D	2.9	mg/L		P
Arsenic-D	<0.04	mg/L		P	Selenium-D	<0.04	mg/L		P
Barium-D	0.024	mg/L		P	Silver-D	<0.002	mg/L		P
Boron-D	<0.01	mg/L		P	Sodium-D	12.7	mg/L		P
Cadmium-D	<0.002	mg/L		P	Zinc-D	0.004	mg/L		P
Calcium-D	129	mg/L		P	Chloride	2.4	mg/L		I
Chromium-D	<0.004	mg/L		P	Fluoride	0.2	mg/L		I
Copper-D	0.004	mg/L		P	Sulfate	185	mg/L	10	I
Iron-D	<0.02	mg/L		P	NO3+NO2-N	0.43	mg/L		C
Lead-D	34.7	mg/L		P	o-Phosphate	0.01	mg/L		I
Magnesium-D	34.7	mg/L		P	TDS	586	mg/L		W
Manganese-D	<0.002	mg/L		P	TSS	33.5	mg/L		W
					Cyanide	<0.01	mg/L		C
					Conductivity	807	umhos		

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello DATE 08/27/93

Joe Costello, Project Manager

SVL ANALYTICAL, INC.

One Government Gulch ▪ P.O. Box 929 ▪ Kellogg, Idaho 83837-0929 ▪ Phone: (208)784-1258 ▪ Fax: (208)783-0891

SVL Job Number: 30721
SVL Sample ID#: W42279

Client COC ID#:

Client: ECHO BAY
Collection Date: 7/07/93 1:30 PM
Date of Receipt: 07/12/93
Date of Report: 07/28/93

Sample: LF-2

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.53	units		W	Molybdenum-D	<0.003	mg/L		P
Alkalinity	265	mg/L		T	Nickel-D	<0.01	mg/L		P
Bicarbonate	265	mg/L		T	Potassium-D	2.6	mg/L		P
Cyanide	<0.01	mg/L		C	Selenium-D	<0.04	mg/L		P
Aluminum-D	<0.01	mg/L		P	Silver-D	<0.002	mg/L		P
Arsenic-D	<0.04	mg/L		P	Sodium-D	11.9	mg/L		P
Barium-D	0.024	mg/L		P	Zinc-D	0.006	mg/L		P
Boron-D	<0.01	mg/L		P	Chloride	2.4	mg/L		I
Cadmium-D	<0.002	mg/L		P	Fluoride	0.3	mg/L		I
Calcium-D	122	mg/L		P	Sulfate	163	mg/L		I
Chromium-D	<0.004	mg/L		P	NO3+NO2-N	0.42	mg/L		C
Copper-D	0.004	mg/L		P	o-Phosphate	<0.01	mg/L		I
Iron-D	<0.02	mg/L		P	Conductance	762	umhos		
Lead-D	<0.04	mg/L		P	TDS	503	mg/L		W
Magnesium-D	33.0	mg/L		P	TSS	16.5	mg/L		W
Manganese-D	<0.002	mg/L		P					
Mercury-D	<0.0002	mg/L		V					

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello by SB DATE 07/30/93
Joe Costello, Project Manager

SVL ANALYTICAL

Formerly Silver Valley Laboratories, Inc.

SVL Job Number: 30578
SVL Sample ID: W40995

Client: ECHO BAY
Collection Date: 06/08/93 12:30 PM
Date of Receipt: 06/11/93
Date of Report: 06/30/93

Sample: LF-2

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.90	units		W	Molybdenum-D	<0.008	mg/L		P
Alkalinity	251	mg/L		T	Nickel-D	<0.01	mg/L		P
Cyanide	<0.01	mg/L		C	Potassium-D	2.7	mg/L		P
Aluminum-D	<0.02	mg/L		P	Selenium-D	<0.04	mg/L		P
Arsenic-D	<0.04	mg/L		P	Silver-D	<0.002	mg/L		P
Barium-D	0.023	mg/L		P	Sodium-D	11.1	mg/L		P
Boron-D	<0.006	mg/L		P	Zinc-D	<0.001	mg/L		P
Cadmium-D	<0.002	mg/L		P	Chloride	2.6	mg/L		I
Calcium-D	113	mg/L		P	Fluoride	0.2	mg/L		I
Chromium-D	<0.002	mg/L		P	Sulfate	172	mg/L		I
Copper-D	0.006	mg/L		P	NO3+NO2-N	0.50	mg/L		C
Iron-D	<0.009	mg/L		P	o-Phosphate	0.57	mg/L		I
Lead-D	<0.04	mg/L		P	Conductance	749	umhos		
Magnesium-D	32.5	mg/L		P	TDS	538	mg/L		W
Manganese-D	<0.001	mg/L		P	TSS	316	mg/L		W
Mercury-D	<0.0002	mg/L		V					

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello/K Gray DATE 07/01/93
Joe Costello, Project Manager

SVL ANALYTICAL
Formerly Silver Valley Laboratories, Inc.

SVL Job Number: 30449
SVL Sample ID: W39862

Client: ECHO BAY
Collection Date: 05/11/93 11:30 AM
Date of Receipt: 05/14/93
Date of Report: 06/08/93

Sample: LF-2

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.70	units		W	Molybdenum-D	<0.008	mg/L		P
Alkalinity	250	mg/L		T	Nickel-D	<0.015	mg/L		P
Bicarbonate	250	mg/L		T	Potassium-D	2.8	mg/L		P
Cyanide	<0.01	mg/L		C	Selenium-D	<0.04	mg/L		P
Aluminum-D	<0.02	mg/L		P	Sodium-D	10.9	mg/L		P
Arsenic-D	<0.04	mg/L		P	Zinc-D	0.006	mg/L		P
Boron-D	<0.006	mg/L		P	Chloride	4.32	mg/L		I
Cadmium-D	<0.002	mg/L		P	Fluoride	0.20	mg/L		I
Calcium-D	126	mg/L		P	Sulfate	227	mg/L		I
Copper-D	<0.004	mg/L		P	NO3+NO2-N	0.76	mg/L		C
Iron-D	<0.009	mg/L		P	o-Phosphate	0.07	mg/L		I
Lead-D	<0.04	mg/L		P	Conductance	848	umhos		
Magnesium-D	37.4	mg/L		P	TDS	513	mg/L		W
Manganese-D	<0.001	mg/L		P	TSS	73.3	mg/L		W
Mercury-D	<0.0002	mg/L		V	Silver-D	<0.002	mg/L		P
Barium-D	0.026	mg/L		P	Chromium-D	0.004	mg/L		P

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello / DATE 06/08/93
Joe Costello, Project Manager

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-2
Sample Collection Date: 4/06/93 11:15 AM
Date of Sample Receipt: 04/09/93
Date of Report: 04/23/93

SVL Job Number: 30299
SVL Sample ID: W38808
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.96	units		W	Molybdenum-D	< .008	mg/L		P
Alkalinity	297.	mg/L		T	Nickel-D	< .01	mg/L		P
Bicarbonate	297.	mg/L		T	Potassium-D	2.8	mg/L		P
WAD Cyanide	< .01	mg/L		C	Selenium-D	< .04	mg/L		P
Aluminum-D	< .02	mg/L		P	Sodium-D	12.1	mg/L		P
Arsenic-D	< .04	mg/L		P	Zinc-D	.013	mg/L		P
Boron-D	< .006	mg/L		P	Chloride	6.54	mg/L		I
Cadmium-D	< .002	mg/L		P	Fluoride	.19	mg/L		I
Calcium-D	174.	mg/L		P	Sulfate	327.	mg/L		I
Copper-D	< .004	mg/L		P	NO3+NO2-N	.92	mg/L		C
Iron-D	.022	mg/L		P	o-Phosphate	.01	mg/L		I
Lead-D	< .04	mg/L		P	Conductance	1050	umhos		
Magnesium-D	49.3	mg/L		P	TDS	782.	mg/L		W
Manganese-D	< .001	mg/L		P	TSS	23.4	mg/L		W
Mercury-D	< .0002	mg/L		V					

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO T=TITRATION W=WET CHEM E=ELECTRODE

CONDUCTIVITY RESULT WAS ADJUSTED TO 25 DEGREES C

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 04/26/93

SVL ANALYTICAL

Client: ECHO BAY - WALT HUNT
Client Sample ID: LF-2
Sample Collection Date: 3/02/93 10:10
Date of Sample Receipt: 03/04/93
Date of Report: 03/16/93

SVL Job Number: 30163
SVL Sample ID: W37686
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.78	units		W	Molybdenum-D	< .007	mg/L		P
Alkalinity	302.	mg/L		T	Nickel-D	< .01	mg/L		P
Bicarbonate	302.	mg/L		T	Potassium-D	2.9	mg/L		P
WAD Cyanide	< .01	mg/L		C	Selenium-D	< .04	mg/L		P
Aluminum-D	< .03	mg/L		P	Sodium-D	13.6	mg/L		P
Arsenic-D	< .04	mg/L		P	Zinc-D	.011	mg/L		P
Boron-D	< .01	mg/L		P	Chloride	6.08	mg/L		I
Cadmium-D	< .002	mg/L		P	Fluoride	.28	mg/L		I
Calcium-D	175.	mg/L		P	Sulfate	321.	mg/L	20	I
Copper-D	.004	mg/L		P	NO3+NO2-N	.68	mg/L		C
Iron-D	< .009	mg/L		P	o-Phosphate	1.84	mg/L		I
Lead-D	< .03	mg/L		P	Conductance	1028.	umhos		
Magnesium-D	42.5	mg/L		P	TDS	754.	mg/L		W
Manganese-D	< .002	mg/L		P	TSS	1560	mg/L		W
Mercury-D	< .0002	mg/L							

C/A BAL: 12.8 %diff CATION SUM: 12.9 meq/L ANION SUM: 10.0 meq/L

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO T=TITRATION W=WET CHEM E=ELECTRODE

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 3/16/93

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF2
Sample Collection Date: 2/03/93 11:20A
Date of Sample Receipt: 02/03/93
Date of Report: 02/19/93

SVL Job Number: 30094
SVL Sample ID: W36831

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.70	units			Mercury-D	< .0002	mg/L		V
Alkalinity	300.	mg/L			Molybdenum- D	< .007	mg/L		P
Bicarbonate	300.	mg/L			Nickel-D	< .01	mg/L		P
WAD Cyanide	< .01	mg/L		C	Potassium-D	2.8	mg/L		P
Aluminum-D	< .03	mg/L		P	Selenium-D	< .04	mg/L		P
Arsenic-D	< .04	mg/L		P	Sodium-D	13.6	mg/L		P
Boron-D	< .01	mg/L		P	Zinc-D	.007	mg/L		P
Cadmium-D	< .002	mg/L		P	Chloride	6.28	mg/L		I
Calcium-D	173.	mg/L		P	Fluoride	.18	mg/L		I
Copper-D	< .003	mg/L		P	Sulfate	289.	mg/L		I
Iron-D	< .009	mg/L		P	NO3+NO2-N	.43	mg/L		C
Lead-D	< .03	mg/L		P	Conductance	1010	umhos		
Magnesium-D	42.6	mg/L		P	TDS	728.	mg/L		
Manganese-D	< .002	mg/L		P	TSS	3110	mg/L		
Ortho-Phosphate	<.01	mg/L			Silver-D	< .005	mg/L		P
Barium-D	.03	mg/L		P	Chromium-D	< .006	mg/L		P

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 02/19/93

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-2
Sample Collection Date: 1/05/93 11:00
Date of Sample Receipt: 01/13/93
Date of Report: 01/25/93

SVL Job Number: 30029
SVL Sample ID: W36253
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.70	units			Potassium-D	2.8	mg/L		P
Alkalinity	303.	mg/L			Selenium-D	< .04	mg/L		P
Bicarbonate	303.	mg/L			Sodium-D	13.3	mg/L		P
WAD Cyanide	< .01	mg/L		C	Zinc-D	.012	mg/L		P
Aluminum-D	.09	mg/L		P	Chloride	6.63	mg/L		I
Arsenic-D	< .04	mg/L		P	Fluoride	.24	mg/L		I
Boron-D	.01	mg/L		P	Sulfate	297.	mg/L		I
Cadmium-D	< .002	mg/L		P	NO3+NO2-N	1.03	mg/L		C
Calcium-D	169.	mg/L		P	o-Phosphate	4.69	mg/L		I
Copper-D	.004	mg/L		P	Conductance	1030	umhos		
Iron-D	.088	mg/L		P	TDS	686.	mg/L		
Lead-D	< .03	mg/L		P	TSS	1950	mg/L		
Magnesium-D	40.0	mg/L		P	Cyanide	< .01	mg/L		C
Manganese-D	< .002	mg/L		P	Barium -D	.030	mg/L		P
Mercury-D	< .0002	mg/L		V	Chromium -D	< .006	mg/L		P
Molybdenum-	< .007	mg/L		P	Silver -D	< .004	mg/L		P
Nickel-D	< .01	mg/L		P					

C/A BAL: 12.6 %diff CATION SUM: 12.4 meq/L ANION SUM: 9.6 meq/L

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 01/25/93

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-2
Sample Collection Date: 12/02/92 NOON
Date of Sample Receipt: 12/07/92
Date of Report: 12/21/92

SVL Job Number: 21571
SVL Sample ID: W35184
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.80	units			Molybdenum-D	< .008	mg/L		P
Alkalinity	301.	mg/L			Nickel-D	< .005	mg/L		P
Bicarbonate	299.	mg/L			Potassium-D	2.5	mg/L		P
WAD Cyanide	< .01	mg/L		C	Selenium-D	< .06	mg/L		P
Aluminum-D	.06	mg/L		P	Silver-D	< .004	mg/L		P
Arsenic-D	< .05	mg/L		P	Sodium-D	14.0	mg/L		P
Barium-D	.034	mg/L		P	Zinc-D	.009	mg/L		P
Boron-D	< .005	mg/L		P	Chloride	5.6	mg/L		I
Cadmium-D	< .004	mg/L		P	Fluoride	.3	mg/L		I
Calcium-D	176.	mg/L		P	Sulfate	287.	mg/L		I
Chromium-D	< .003	mg/L		P	NO3+NO2-N	.49	mg/L		C
Copper-D	< .004	mg/L		P	o-Phosphate	5.60	mg/L		I
Iron-D	.083	mg/L		P	Conductance	1010	mg/L		
Lead-D	< .05	mg/L		P	TDS	875.	mg/L		
Magnesium-D	42.2	mg/L		P	TSS	1830	mg/L		
Manganese-D	.005	mg/L		P	Oil & Grease	<1.0	mg/L		
Mercury-D	< .0002	mg/L							

M(ethod): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 12/22/92

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-2
Sample Collection Date: 11/10/92 11:15AM
Date of Sample Receipt: 11/16/92
Date of Report: 12/02/92

SVL Job Number: 21503
SVL Sample ID: W34650
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M
pH	7.80	units		
Alkalinity	285.	mg/L		
Bicarbonate	285.	mg/L		
WAD Cyanide	< .01	mg/L		C
Aluminum-D	.14	mg/L		P
Arsenic-D	< .04	mg/L		P
Barium-D	.036	mg/L		P
Boron-D	< .06	mg/L		P
Cadmium-D	< .002	mg/L		P
Calcium-D	158.60	mg/L		P
Chromium-D	< .003	mg/L		P
Copper-D	.005	mg/L		P
Iron-D	.183	mg/L		P
Lead-D	< .04	mg/L		P
Magnesium-D	41.36	mg/L		P
Manganese-D	.007	mg/L		P
Mercury-D	< .0002	mg/L		V
Molybdenum-D	< .007	mg/L		P
Nickel-D	< .02	mg/L		P
Potassium-D	2.47	mg/L		P
Selenium-D	< .040	mg/L		P
Silver-D	< .002	mg/L		P
Sodium-D	15.67	mg/L		P
Zinc-D	.016	mg/L		P
Chloride	4.3	mg/L		I
Fluoride	.3	mg/L		I
Sulfate	275.0	mg/L		I
NO3+NO2-N	.44	mg/L		C
o-Phosphate	1.19	mg/L		
Conductance	956.	umhos		
TDS	715.	mg/L		
TSS	638.3	mg/L		
Oil & Grease	--NA--			

M(ethod): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY
--NA-- : NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:
M. Bencich by SH DATE 12/02/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-2
Sample Collection Date: 10/14/92 10:45AM
Date of Sample Receipt: 10/19/92
Date of Report: 11/16/92 REVISED

SVL Job Number: 21387
SVL Sample ID: W33389
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	ANALYTE	RESULT	UNIT	DILN
Silver	< .004	mg/L		Selenium	< .062	mg/L	
Aluminum	22.3	mg/L		Zinc	.257	mg/L	
Arsenic	.108	mg/L		Mercury	.0002	mg/L	
Boron	.066	mg/L		Chloride	4.68	mg/L	
Barium	.347	mg/L		Fluoride	.32	mg/L	
Calcium	174.7	mg/L		Sulfate	265.2	mg/L	
Cadmium	.005	mg/L		Alkalinity	300.	mg/L	
Chromium	.049	mg/L		Conductance	976.	mg/L	
Copper	.213	mg/L		TDS	716.	mg/L	
Iron	48.4	mg/L		TSS	473.3	mg/L	
Potassium	6.85	mg/L		Oil & Grease	--NA--		
Magnesium	53.2	mg/L		o-Phosphate	.11	mg/L	
Manganese	.676	mg/L		Bicarbonate	300.	mg/L	
Molybdenum	< .008	mg/L		pH	8.0	units	
Sodium	16.6	mg/L		NO3+NO2-N	.50	mg/L	
Nickel	.055	mg/L		WAD Cyanide	< .01	mg/L	
Lead	< .049	mg/L					

--NA-- NOT ANALYZED

DISSOLVED METALS

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

Kelli Dencich by dc DATE 11/16/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-2
Sample Collection Date: 09/08/92 10:00 AM
Date of Sample Receipt: 09/11/92
Date of Report: 9/29/92

SVL Job Number: 21163
SVL Sample ID: W30853
Area:
Matrix: WATER

ANALYTE		RESULT	UNIT	DILN
pH		7.88	units	
Alkalinity		265.	mg/L	
Bicarbonate		265.	mg/L	
WAD Cyanide	<	.01	mg/L	
Aluminum-D	<	.04	mg/L	
Arsenic-D		.035	mg/L	
Barium-D		.032	mg/L	
Boron-D	<	.02	mg/L	
Cadmium-D	<	.003	mg/L	
Calcium-D		166.60	mg/L	
Chromium-D	<	.005	mg/L	
Copper-D	<	.005	mg/L	
Iron-D		.04	mg/L	
Lead-D		.012	mg/L	
Magnesium-D		48.16	mg/L	
Manganese-D		.002	mg/L	
Mercury-D	<	.0002	mg/L	
Molybdenum-D	<	.02	mg/L	
Nickel-D	<	.02	mg/L	
Potassium-D		3.	mg/L	
Selenium-D	<	.002	mg/L	
Silver-D	<	.006	mg/L	
Sodium-D		11.68	mg/L	
Zinc-D		.006	mg/L	
Chloride		5.7	mg/L	
Fluoride		.3	mg/L	
Sulfate		326.0	mg/L	
NO3+NO2-N		.41	mg/L	
o-Phosphate		3.30	mg/L	
Conductance		1020	umhos	
TDS		746.	mg/L	
TSS		930.0	mg/L	
Oil & Grease		--NA--		

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 09/29/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-2
Sample Collection Date: 08/05/92 NOON
Date of Sample Receipt: 08/07/92
Date of Report: 8/24/92

SVL Job Number: 20937
SVL Sample ID: W28555
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	ANALYTE	RESULT	UNIT	DILN
Silver-D	< .004	mg/L		Selenium-D	< .064	mg/L	
Aluminum-D	.39	mg/L		Zinc-D	.011	mg/L	
Arsenic-D	< .035	mg/L		Mercury-D	< .0002	mg/L	
Boron-D	.01	mg/L		Chloride	4.7	mg/L	
Barium-D	.033	mg/L		Fluoride	290.0	mg/L	
Calcium-D	147.00	mg/L		Sulfate	.3	mg/L	
Cadmium-D	< .003	mg/L		Alkalinity	259.	mg/L	
Chromium-D	< .004	mg/L		Conductance	955.	umhos	
Copper-D	.005	mg/L		TDS	1414	mg/L	
Iron-D	.65	mg/L		TSS	3096	mg/L	
Potassium-D	3.	mg/L		Oil & Grease	--NA--		
Magnesium-D	41.30	mg/L		o-Phosphate	4.72	mg/L	
Manganese-D	.012	mg/L		Bicarbonate	259.	mg/L	
Molybdenum-D	< .008	mg/L		pH	7.85	units	
Sodium-D	9.91	mg/L		NO3+NO2-N	.40	mg/L	
Nickel-D	< .010	mg/L		WAD Cyanide	< .01	mg/L	
Lead-D	< .041	mg/L					

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

Kreeba Bencich by dc DATE 08/25/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-2
Sample Collection Date: 07/08/92 12:15 PM
Date of Sample Receipt: 07/14/92
Date of Report: 7/28/92

SVL Job Number: 20797
SVL Sample ID: W27178
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN
pH	8.00	units	
Alkalinity	287.	mg/L	
Bicarbonate	287.	mg/L	
WAD Cyanide	< .01	mg/L	
Aluminum-D	.09	mg/L	
Arsenic-D	< .002	mg/L	
Barium-D	.034	mg/L	
Boron-D	< .02	mg/L	
Cadmium-D	< .003	mg/L	
Calcium-D	173.50	mg/L	
Chromium-D	< .005	mg/L	
Copper-D	.007	mg/L	
Iron-D	.16	mg/L	
Lead-D	< .001	mg/L	
Magnesium-D	46.50	mg/L	
Manganese-D	.009	mg/L	
Mercury-D	< .0002	mg/L	
Molybdenum-D	< .02	mg/L	
Nickel-D	< .02	mg/L	
Potassium-D	3.	mg/L	
Selenium-D	< .002	mg/L	
Silver-D	< .006	mg/L	
Sodium-D	9.98	mg/L	
Zinc-D	.019	mg/L	
Chloride	4.6	mg/L	
Fluoride	.3	mg/L	
Sulfate	286.0	mg/L	
NO3+NO2-N	.48	mg/L	
o-Phosphate	< .01	mg/L	
Conductance	994.	umhos	
TDS	699.	mg/L	
TSS	585.6	mg/L	
Oil & Grease	--NA--		

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

M. Bencich by sll DATE 07/29/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-2
Sample Collection Date: 06/09/92 10:15AM
Date of Sample Receipt: 06/15/92
Date of Report: 6/30/92

SVL Job Number: 20666
SVL Sample ID: W25739
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	ANALYTE	RESULT	UNIT	DILN
pH	7.65	units		Mercury-D	.0002	mg/L	
Alkalinity	270.	mg/L		Molybdenum-D	< .02	mg/L	
Bicarbonate	270.	mg/L		Nickel-D	< .02	mg/L	
WAD Cyanide	< .01	mg/L		Potassium-D	3.	mg/L	
Aluminum-D	.27	mg/L		Selenium-D	< .05	mg/L	
Arsenic-D	< .04	mg/L		Silver-D	< .006	mg/L	
Barium-D	.033	mg/L		Sodium-D	9.73	mg/L	
Boron-D	< .02	mg/L		Zinc-D	.010	mg/L	
Cadmium-D	< .003	mg/L		Chloride	4.7	mg/L	
Calcium-D	147.20	mg/L		Fluoride	.3	mg/L	
Chromium-D	< .005	mg/L		Sulfate	267.0	mg/L	20X
Copper-D	.006	mg/L		NO3+NO2-N	.47	mg/L	
Iron-D	.43	mg/L		o-Phosphate	5.12	mg/L	
Lead-D	< .04	mg/L		Conductance	904.	umhos	
Magnesium-D	42.01	mg/L		TDS	691.	mg/L	
Manganese-D	.006	mg/L		TSS	1750	mg/L	
				Cyanide	< .01	mg/L	

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

M. Bencich by SH DATE 06/30/92

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-2
Sample Collection Date: 05/05/92 8:45AM
Date of Sample Receipt: 05/07/92
Date of Report: 5/19/92

SVL Job Number: 20489
SVL Sample ID: W24377
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	ANALYTE	RESULT	UNIT	DILN
pH	7.89	units		Mercury-D	< .0002	mg/L	
Alkalinity	264.	mg/L		Molybdenum-D	< .02	mg/L	
Bicarbonate	264.	mg/L		Nickel-D	< .02	mg/L	
WAD Cyanide	< .01	mg/L		Potassium-D	3.	mg/L	
Aluminum-D	.33	mg/L		Selenium-D	.003	mg/L	
Arsenic-D	.033	mg/L		Silver-D	--NA--		
Barium-D	--NA--			Sodium-D	9.21	mg/L	
Boron-D	< .02	mg/L		Zinc-D	.013	mg/L	
Cadmium-D	< .003	mg/L		Chloride	6.4	mg/L	
Calcium-D	176.90	mg/L		Fluoride	.4	mg/L	
Chromium-D	--NA--			Sulfate	319.0	mg/L	
Copper-D	.007	mg/L		NO3+NO2-N	.55	mg/L	
Iron-D	.60	mg/L		o-Phosphate	< .05	mg/L	
Lead-D	.002	mg/L		Conductance	955.	umhos	
Magnesium-D	47.44	mg/L		TDS	776.	mg/L	
Manganese-D	.021	mg/L		TSS	1658	mg/L	

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

Melva Bencich by BL DATE 05/20/92

File 23295-DATA

SVL ANALYTICAL

Client: ECHO BAY MINERALS, INC.
Client Sample ID: LF-2
Sample Collection Date: 04/07/92
Date of Sample Receipt: 04/14/92
Date of Report: 5/ 1/92

SVL Job Number: 20387
SVL Sample ID: W23622
Time: 2 PM
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	ANALYTE	RESULT	UNIT	DILN
pH	7.89	units		Molybdenum-D	< .02	mg/L	
Alkalinity	292.	mg/L		Nickel-D	< .02	mg/L	
Bicarbonate	292.	mg/L		Potassium-D	3.	mg/L	
WAD Cyanide	< .01	mg/L		Selenium-D	.020	mg/L	
Aluminum-D	< .04	mg/L		Sodium-D	12.40	mg/L	
Arsenic-D	< .002	mg/L		Zinc-D	.025	mg/L	
Boron-D	< .02	mg/L		Chloride	8.5	mg/L	
Cadmium-D	< .003	mg/L		Fluoride	.3	mg/L	
Calcium-D	174.10	mg/L		Sulfate	335.0	mg/L	
Copper-D	.009	mg/L		NO3+NO2-N	.52	mg/L	
Iron-D	.04	mg/L		o-Phosphate	.17	mg/L	
Lead-D	< .001	mg/L		Conductance	1078	umhos	
Magnesium-D	49.08	mg/L		TDS	799.	mg/L	
Manganese-D	.002	mg/L		TSS	103.2	mg/L	
Mercury-D	< .0002	mg/L		Oil & Grease	--NA--		

--NA-- NOT ANALYZED

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

M Bencich by SH DATE 05/04/92

ECHO BAY MINERALS - KETTLE RIVER OPERATION
MONTHLY GROUNDWATER DATA

STATION	DATE	TIME	WELL TD	DEPTH TO WATER	pH	TEMP. (C)	CONDUCTIVITY (umho)	Comments
LF1	10/18/92	1:10p	25.0		7.5	5	887	
LF1	04/07/92	1:30p	25.0	9.9	7.9	5	921	
LF1	05/05/92	9:00a	25.0	9.3	7.8	5	906	
LF1	06/09/92	10:30a	25.0	9.9	7.7	6	892	
LF1	07/08/92	12:15p	25.0	10.0	7.8	6	902	
LF1	08/05/92	12:00p	25.0					No Access
LF1	09/08/92	10:00a	25.0					No Access
LF1	10/14/92	10:30a	25.0	10.2	7.7	5	910	
LF1	11/10/92	11:30a	25.0	10.6	7.8	4	906	
LF1	12/02/92	12:15p	25.0	10.2	7.8	4	946	
LF1	01/05/93	10:45a	25.0	10.2	7.3	4	902	
LF2	10/18/91	11:45a	36.0	7.2	7.3	5	936	
LF2	04/07/92	2:00p	36.0	13.0	7.8	5	1170	
LF2	05/05/92	8:45a	36.0	13.8	7.7	5	1100	
LF2	06/09/92	10:15a	36.0	16.0	7.4	6	1040	
LF2	07/08/92	12:15p	36.0	16.4	7.5	6	1110	
LF2	08/05/92	12:00p	36.0	19.1	7.8	6	1096	
LF2	09/08/92	10:00a	36.0	22.2	7.5	7	1020	
LF2	10/14/92	10:45a	36.0	25.0	7.8	5	1000	
LF2	11/10/92	11:15p	36.0	27.8	7.7	5	1040	
LF2	12/02/92	12:00a	36.0	27.8	7.5	5	1100	
LF2	01/05/93	11:00a	36.0	29.0	7.3	4	1105	

INFILTRATION POND LF-I

| ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM |
| 11/23/93 Water Analysis Report 11:35 |

Client : Echo Bay Minerals Company
Address : 921 Fish Hatchery Rd.
Republic, WA 99166
Attn. : Mr. W. Hunt
Project :
Sample ID: LF-I
Sample Date Time: 11/02/93 13:30

Lab No. : 93-WI/11372
Date Received: 11/05/93

Parameters		
Alkalinity as CaCO3	208.	mg/l
Bicarbonate as CaCO3	208	mg/l
Calcium, dissolved	154.	mg/l
Carbonate as CaCO3	0.	mg/l
Chloride	72.	mg/l
Conductivity @ 25C	2150.	umhos/cm
Magnesium, dissolved	86.	mg/l
Nitrate as N, dissolved	136.00	mg/l
Nitrate/Nitrite as N	147.	mg/l
Nitrite as N, dissolved	11.	mg/l
pH (lab)	8.3	units
Potassium, dissolved	21.	mg/l
Phosphorus, ortho diss	0.049	mg/l
Sodium, dissolved	63.	mg/l
Sulfate	545.	mg/l
Cation-Anion Balance	1.26	%
Solids, total dissolved	978.	mg/l
Solids, total suspended	-2.	mg/l
Turbidity	0.63	ntu
Arsenic, dissolved	0.004	mg/l
Barium, dissolved	.04	mg/l
Cadmium, dissolved	-0.005	mg/l
Chromium, dissolved	-0.01	mg/l
Copper, dissolved	-0.01	mg/l
Lead, dissolved	-0.02	mg/l
Manganese, dissolved	0.05	mg/l
Mercury, dissolved	-0.0002	mg/l
Molybdenum, dissolved	0.03	mg/l
Nickel, dissolved	-0.02	mg/l
Selenium, dissolved	0.005	mg/l
Silver, dissolved	-0.01	mg/l
Zinc, dissolved	0.03	mg/l

Remarks:

Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager/S.H.

Frank E. Polniak, Inorganic Laboratory Supervisor/FP

Entity Name: Echo Bay Exploration County: Ferry

DISCHARGE MONITORING REPORT

Permit No. ST 8033 Plant Type: Infiltration Ponds, Tailings Ponds Month November Year 1993

sample point	Lamefoot Mine - Infiltration Pond								Key Project Open Pit Mines									
	Outlet of Settling Ponds								Inlet to Infiltration Pond # 1									
param.	pH	Conductivity	TSS	NO_3 (as N)	Copper	Zinc	Lead	Mercury	pH	Conductivity	TSS	NH_3 (as N)	NO_3 (as N)	Copper	Zinc	Lead	Mercury
freq.	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	1/mo
Date	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1										Dry							
2	7.9	2310	4.0	136	<0.01	0.03	<0.02										
3	8.0	2220	lost by														
4																	
5	7.8	2960	6														
6																	
7																	
8	8.0	2570	9														
9	7.9	2625	36														
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	
21																	
22																	
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30																	
31																	
Max.	8	2960	36	136	0	0.03	0	0	0	0	0	0	0	0	0	0	0
Min.	7.8								0								
Avg.	7.9	2537	11	136	0	0.03	0	0	0	0	0	0	0	0	0	0	0

I CERTIFY UNDER PENALTY OF LAW, THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR WILLFUL VIOLATIONS.

Remarks: INFILTRATION POND FROZEN AFTER 11/10/93

Signature:

Title:

Phone No.

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
ttn. : Accounts Payable cc: George Swank
Project :

Sample ID: LF-I
Sample Date Time: 10/06/93 13:00

Lab No. : 93-WI/10448
Date Received: 10/08/93

Parameters		
Nitrate as N, dissolved	59.80	mg/l
Nitrate/Nitrite as N	65.2	mg/l
Nitrite as N, dissolved	5.4	mg/l
Copper, total recov.	0.01	mg/l
Lead, total recov.	-0.02	mg/l
Mercury, total recov.	-0.0002	mg/l
Zinc, total recov.	0.06	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager/SH.

Frank E. Polniak, Inorganic Laboratory Supervisor/

Entity Name: Echo Bay Exploration County: Ferry

DISCHARGE MONITORING REPORT

Permit No. ST 8033 Plant Type: Infiltration Ponds, Tailings Ponds Month October Year 1993

sample point	Lamefoot Mine - Infiltration Pond Outlet of Settling Ponds								Key Project Open Pit Mines Inlet to Infiltration Pond # 1								
param.	pH	Conductivity	TSS	NO_3 (as N)	Copper	Zinc	Lead	Mercury	pH	Conductivity	TSS	NH_3 (as N)	NO_3 (as N)	Copper	Zinc	Lead	Mercury
freq.	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	1/mo
Date	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1																	
2																	
3																	
4																	
5	8.2	1923															
6	8.1	2410	82.0	59.8	0.01	<0.06	<0.02	<0.002	8								
7	8.2	2510	36.0														
8																	
9																	
10																	
11																	
12																	
13	8.1	2790	52.0														
14	8.1	2800	51.0														
15	8.0	1020	13.0														
16																	
17																	
18	8.0	1876	2.0														
19																	
20	8.0	2310	20.0														
21			285														
22																	
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30																	
31																	
Max.	8.2	2800	285	59.8	0.01	NA	NA	NA	8	NA	NA	NA	NA	NA	NA	NA	NA
Min.	8								8								
Avg.		2205	67.6	59.8	0.01	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA

I CERTIFY UNDER PENALTY OF LAW, THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR WILLFUL VIOLATIONS.

Remarks: INFILTRATION POND FROZEN AFTER 10/21/93

Signature:

Title:

Phone No.

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc.
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99166
Attn: George Swank

Report Number: E-1543

Sample ID	mg/l TSS
LFI 9-24-93	2.0
LFI 9-27-93	5.0
LFI 9-29-93	52.0
LFI 9-30-93	32.0
LFI 10-06-93	82.0
LFI 10-07-93	36.0
LFI 10-13-93	52.0
LFI 10-14-93	51.0
LFI 10-15-93	13.0
LFI 10-18-93	2.0
LFI 10-20-93	20.0
LFI 10-21-93	285.0

Date: October 15, 1993

Signed: John Trechter

ACZ LABORATORIES INC DATA MANAGEMENT SYSTEM
10/14/93 Water Analysis Report 17:08
Page 1

Client : Echo Bay Minerals, Inc.
Address : 921 Fish Hatchery Road
Republic, Washington 99166
Attn. : Accounts Payable cc: George Swank
Project :

Sample ID: LFI
Sample Date Time: 09/15/93 13:00

Lab No. : 93-WI/09578
Date Received: 09/17/93

Parameters		
Nitrate as N, dissolved	64.40	mg/l
Nitrate/Nitrite as N	70.96	mg/l
Nitrite as N, dissolved	6.56	mg/l
Copper, total recov.	0.02	mg/l
Lead, total recov.	-.02	mg/l
Mercury, total recov.	-0.0002	mg/l
Zinc, total recov.	0.05	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager

Frank E. Polniak, Inorganic Laboratory Supervisor

Entity Name: Echo Bay Exploration County: Ferry **DISCHARGE MONITORING REPORT**

Permit No. ST 8033 Plant Type: Infiltration Ponds, Tailings Ponds Month September Year 1993

sample point	**Lamefoot Mine - Infiltration Pond**								**Key Project Open Pit Mines**								
	Outlet of Settling Ponds								Inlet to Infiltration Pond # 1								
param.	pH	Conductivity	TSS	NO_3 (as N)	Copper	Zinc	Lead	Mercury	pH	Conductivity	TSS	NH_3 (as N)	NO_3 (as N)	Copper	Zinc	Lead	Mercury
freq.	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	1/mo
Date	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	8.0	1005	8.0						Dry								
2																	
3																	
4																	
5																	
6																	
7	8.0	1323	1.0														
8	7.9	1010	9.0														
9	8.1	957	3.0														
10																	
11																	
12																	
13																	
14	8.0	1010	338.0														
15	8.1	1920	18.0	70.96	0.02	0.05	<0.02	<0.0002									
16	8.0	2120	48.0														
17																	
18																	
19																	
20																	
21	8.1	1987	50.0														
22			73.0														
23	8.0	2400															
24	8.0	1333	2.0														
25																	
26																	
27	7.9	1660	5.0														
28																	
29	8.1	1688	52.0														
30	8.0	2230	32.0														
Max.	8.1	2400	338.0	70.96	0.02	0.05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Min.	7.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Avg.	[illegible]	1588	49.2	70.96	0.02	0.05	NA	NA	[illegible]	NA	NA	NA	NA	NA	NA	NA	NA

I CERTIFY UNDER PENALTY OF LAW, THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR WILLFUL VIOLATIONS.

Remarks: ____________________

Signature: ____________________

Title: ____________________

Phone No. ____________________

August 2, 1993

Entity Name: Echo Bay Exploration County: Ferry **DISCHARGE MONITORING REPORT**

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc.
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99166
Attn: Walt Hunt

Report Number: E-1543

Sample ID	mg/l TSS
LFI 9-24-93	2.0
LFI 9-27-93	5.0
LFI 9-29-93	52.0
LFI 9-30-93	32.0

Date: October 15, 1993

Signed:

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99116
Attn: Walt Hunt

Report Number: E-1467

Sample ID	mg/l TSS
KPI #3 8-25-93	1135.0
LFI 8-30-93	6.0
LFI 8-31-93	39.0
KPI #3 8-31-93	15.0
LFI 9-01-93	8.0
KPI #3 9-02-93	37.0
LFI 9-7-93	1.0
LFI 9-8-93	9.0
LFI 9-9-93	3.0
LFI 9-14-93	338.0
LFI 9-15-93	18.0
LFI 9-16-93	48.0
LFI 9-21-93	50.0
LFI 9-23-93	73.0

Date: September 10, 1993

Signed: John Trechter

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99116
Attn: Walt Hunt

Report Number: E-1467

Sample ID	mg/l TSS
KPI #3 8-25-93	1135.0
LFI 8-30-93	6.0
LFI 8-31-93	39.0
KPI #3 8-31-93	15.0
LFI 9-01-93	8.0
KPI #3 9-02-93	37.0

Partial Report

Date: September 10, 1993

Signed: Heather

SVL ANALYTICAL, INC.
One Government Gulch ▪ P.O. Box 929 ▪ Kellogg, Idaho 83837-0929 ▪ Phone: (208)784-1258 ▪ Fax: (208)783-0891

SVL Job Number: 30907
SVL Sample ID#: W44215

Client: ECHO BAY
Collection Date: 8/05/93 1:45P
Date of Receipt: 08/09/93
Date of Report: 08/26/93

Sample: LF-I

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	6.83	units		E	Mercury	<0.0002	mg/L		V
Copper	0.019	mg/L		P	Zinc	0.075	mg/L		P
Lead	<0.04	mg/L		P	TSS	15.6	mg/L		W
					Nitrate-N	1.63	mg/L		
					Conductivity	1520	umhos		

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello DATE 08/27/93

Joe Costello, Project Manager

August 2, 1993

Entity Name: Echo Bay Exploration County: Ferry

DISCHARGE MONITORING REPORT

Permit No. ST 8033 Plant Type: Infiltration Ponds, Tailings Ponds Month August Year 1993

sample point	Lamefoot Mine - Infiltration Pond								Key Project Open Pit Mines								
	Outlet of Settling Ponds								Inlet to Infiltration Pond # 1								
param.	pH	Conductivity	TSS	NO_3 (as N)	Copper	Zinc	Lead	Mercury	pH	Conductivity	TSS	NH_3 (as N)	NO_3 (as N)	Copper	Zinc	Lead	Mercury
freq.	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	1/mo
Date	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1									Dry								
2	7.9	1157	48.0														
3																	
4	7.9	1054	35.0														
5	6.8	1520	15.6	1.63	0.019	0.075	<.04	<.0002									
6																	
7																	
8																	
9	8.1	1116	2.0														
10																	
11	8.0	1020	42.0														
12	7.9	938	46.0														
13																	
14																	
15																	
16																	
17	8.0	1597	14.0														
18																	
19																	
20	7.6	2100	37.0														
21																	
22																	
23																	
24	8.0	822	23.0														
25	8.0	2330	51.0														
26																	
27																	
28																	
29																	
30	8.0	1932	6.0														
31	7.9	2540	39.0														
Max.	8.1	2540	51.0	1.63	0.019	0.075	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Min.	6.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Avg.	[illegible]	1511	29.9	1.63	0.019	0.075	NA	NA	[illegible]	NA	NA	NA	NA	NA	NA	NA	NA

I CERTIFY UNDER PENALTY OF LAW, THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR WILLFUL VIOLATIONS.

Remarks: ______

Signature: ______

Title: ______

Phone No. ______

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc.
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99166
Attn: Walt Hunt

Report Number: E-1397

Sample ID	mg/l TSS
LFI 3:00PM 7-22-93	17.0
KPI-3 8:00AM 8-2-93	3127.0
LFI 11:00AM 8-2-93	48.0
LFI 11:30AM 8-4-93	35.0
KPI-3 9:00AM 8-7-93	7.0
LFI 8:30AM 8-5-93	6.0
LFI 7:30AM 8-9-93	2.0
LFI 7:00AM 8-11-93	42.0
KPI-3 9:00AM 8-13-93	12.0
LFI 7:00AM 8-12-93	46.0
KPI-3 8-9-93	67.0
KPI-3 8:00AM 8-11-93	10.0
KPI-3 8:00AM 8-16-93	3.0
LFI 7:00AM 8-17-93	14.0
LFI 8-18-93	9.0
KPI-3 5:00PM 8-19-93	18.0
KPI-3 10:00AM 8-21-93	18,070.0
LFI 10:00AM 8-20-93	37.0
KPI-3 8-23-93	48,700.0
LFI 8:00AM 8-24-93	23.0
LFI 7:00AM 8-25-93	51.0

Date: August 11, 1993

Signed:

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc.
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99166
Attn: Walt Hunt

Report Number: E-1397

Sample ID	mg/l NO_3-N	mg/l NH_3-N
LFI 3:00PM 7-22-93	20.00	---
Pond 8-3-93	54.00	<0.01
KPI-3 8:00AM 8-2-93	8.00	---
LFI 11:00AM 8-2-93	17.00	---
LFI 11:00 AM 8-4-93	16.00	---
Pond 8-9-93	29.00	<0.01
LFI 8:30AM 8-5-93	6.00	---
Pond 8-30-93	---	<0.01
Pond 8-23-93	---	<0.04
POnd 8-16-93	---	<0.01

Date: August 11, 1993

Signed:

SVL ANALYTICAL, INC.
One Government Gulch ▪ P.O. Box 929 ▪ Kellogg, Idaho 83837-0929 ▪ Phone: (208)784-1258 ▪ Fax: (208)783-0891

SVL Job Number: 30721
SVL Sample ID#: W42276

Client COC ID#:

Client: ECHO BAY
Collection Date: 7/07/93 2 PM
Date of Receipt: 07/12/93
Date of Report: 07/28/93

Sample: LFI

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.29	units		W	Zinc-D	0.033	mg/L		P
Copper-D	0.008	mg/L		P	NO3+NO2-N	54.0	mg/L		C
Lead-D	<0.04	mg/L		P	Conductance	1400	umhos		
Mercury-D	<0.0002	mg/L		V	TSS	17.9	mg/L		W

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello by DATE 07/30/93
Joe Costello, Project Manager

Entity Name: Echo Bay Exploration County: Ferry **DISCHARGE MONITORING REPORT**

Permit No. ST 8033 Plant Type: Infiltration Ponds, Tailings Ponds Month July Year 1993

sample point	Lamefoot Mine - Infiltration Pond								Key Project Open Pit Mines								
	Outlet of Settling Ponds								Inlet to Infiltration Pond # 1								
param.	pH	Conductivity	TSS	NO_3 (as N)	Copper	Zinc	Lead	Mercury	pH	Conductivity	TSS	NH_3 (as N)	NO_3 (as N)	Copper	Zinc	Lead	Mercury
freq.	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	1/mo
Date	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	8.1	1686	288.0						Dry								
2																	
3																	
4																	
5																	
6	8.0	935	47.0														
7	7.9	1450	17.9	54	0.008	0.033	<.04	<.0002									
8	7.8	1450	19.3														
9																	
10																	
11																	
12																	
13																	
14	8.1	2050	36.0														
15																	
16																	
17																	
18																	
19																	
20	8.0	1040	12.0														
21																	
22	8.0	1120	17.0														
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30																	
31																	
Max.	8.1	2050	288	54	0.008	0.033	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Min.	7.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			NA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Avg.	[illegible]	1390	62	54	0.008	0.033	NA	NA	[illegible]	NA	NA	NA	NA	NA	NA	NA	NA

I CERTIFY UNDER PENALTY OF LAW, THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR WILLFUL VIOLATIONS.

Remarks: Two LFi samples missed at end of month

Signature:

Title:

Phone No.

August 2, 1993

Entity Name: Echo Bay Exploration County: Ferry **DISCHARGE MONITORING REPORT**

Permit No. ST 8033 Plant Type: Infiltration, Ponds, Tailings Ponds Month July Year 1993

sample point	Lamefoot Mine - Infiltration Pond								Key Project Open Pit Mines								
	Outlet of Settling Ponds								Inlet to Infiltration Pond # 1								
param.	pH	Conductivity	TSS	NO_3 (as N)	Copper	Zinc	Lead	Mercury	pH	Conductivity	TSS	NH_3 (as N)	NO_3 (as N)	Copper	Zinc	Lead	Mercury
freq.	3/wk	3/wk	2/wk	1/mo	1/mo	1/mo	1/mo	1/mo	3/wk	3/wk	3/wk	1/mo	1/mo	1/mo	1/mo	1/mo	1/mo
Date	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	s.u.	µmhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	8.1	1625	228.0						Dry								
2																	
3																	
4																	
5																	
6	8.0	935	47.0														
7	7.9	1430	17.9	54	0.008	0.033	<.04	<.0002									
8	7.8	1450	19.3														
9																	
10																	
11																	
12																	
13																	
14	8.1	2050	36.0														
15																	
16																	
17																	
18																	
19																	
20	8.0	1040	12.0														
21																	
22	8.0	1120	17.9														
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30																	
31																	
Max.	8.1	2050	228	54	0.008	0.033	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Min.	7.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Avg.	[illegible]	1390	62	54	0.008	0.033	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

I CERTIFY UNDER PENALTY OF LAW, THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR WILLFUL VIOLATIONS.

Remarks: Two LFI samples missed at end of month

Signature:

Title:

Phone No.

August 2, 1991

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc.
Kettle River Project
921 Fish Hatchery Rd.
Republic, WA 99166
Attn: Walt Hunt

Report Number: E-1252

Sample ID	mg/l TSS	mg/l NO_3-N	mg/l NH_3-N
LFI 6-9-93 7:30AM	4388	31.00	---
LFI 6-10-93 12:40 PM	514	81.00	---
LFI 6-11-93 2:00 PM	16	21.00	---
LFI 6-14-93 11:00 AM	642	20.00	---
LFI 6-15-93 10:30 AM	14	19.00	---
LFI 6-17-93 11:00 AM	23	72.00	---
Pond 6-21-93	---	77.00	<0.01
KPI-2 6-15-93 9:30 AM	13	---	---
KPI-3 6-21-93 2:15 PM	56	---	---
LFI 6-22-93 2:00 PM	1	0.13	---
LFI 6-23-93 10:30 AM	28	51.00	---
LFI 6-24-93 11:30 AM		78.00	---
KPI-3 6-26-93 9:00 AM	40	---	---
KPI 6-28-93 8:30 AM	106	---	---
#2 6-14-93	---	---	<0.01

Partial Report

Date: July 13, 1993

Signed:

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc.
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99166
ATTN: Walt Hunt

Report Number: E-1262

Sample ID 6-1-93	mg/l NO_3-N	mg/l NH_3-N	mg/l TSS
Pond 5-26-93	---	0.03	---
nd 5-31-93	0.78	0.01	---
OL #1 6-1-93	12.00	0.05	---
LF-I 6-2-93	53.00	---	8.0
LF-I 6-3-93	52.00	---	71.0
LF-I 5-26-93	---	---	270.0
LF-I 5-28-93	---	---	82.0
KPI-3 5-26-93	1:00pm	---	2.0
KPI-3 5-28-93	1:00pm	---	197.0
KPI-3 5-31-93	8:00am	---	3.0
KPI-3 6-02-93	8:30am	---	11.0
KPI-3 6-04-93	8:00am	---	17.0

Date: June 16, 1993

Signed:

SVL ANALYTICAL
Formerly Silver Valley Laboratories, Inc.

SVL Job Number: 30578
SVL Sample ID: W40991

Client: ECHO BAY
Collection Date: 06/08/93 1:00 PM
Date of Receipt: 06/11/93
Date of Report: 06/30/93

Sample: LF-I

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.17	units		W	Lead	<0.04	mg/L		P
Conductance	0.2	umhos			Zinc	0.035	mg/L		P
Copper	0.014	mg/L		P	Mercury	<0.0002	mg/L		V
NO3+NO2-N	61.7	mg/L		C	TSS	182	mg/L		W

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello/K Gray DATE 07/01/93
Joe Costello, Project Manager

SVL ANALYTICAL
Formerly Silver Valley Laboratories, Inc.

SVL Job Number: 30449
SVL Sample ID: W39870

Client: ECHO BAY
Collection Date: 05/11/93 11:00 AM
Date of Receipt: 05/14/93
Date of Report: 06/08/93

Sample: LF-I

Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.56	units		W	Zinc	0.165	mg/L		P
Copper	0.035	mg/L		P	Conductance	1330	umhos		
Lead	<0.04	mg/L		P	TSS	358	mg/L		W
Mercury	<0.0002	mg/L		V	NO3-N	33.3	mg/L		

M(ethods): P=200.7 F=GFAA V=245.2 C=COLORIMETRIC I=300.0 L=EPA600/2-78-054 T=TITRATION W=WET CHEM E=ELECTRODE

This report has been reviewed and is certified to be accurate:

Joe Costello / DATE 06/08/93
Joe Costello, Project Manager

Sample ID	mg/l TSS
7:30am KP-I #1 5-05-93	11.0
7:45am KP-I #2 5-05-93	<1.0
7:50am KP-I #3 5-05-93	96.0
1:00pm KP-I #1 5-07-93	12.0
1:10pm KP-I #2 5-07-93	8.0
1:20pm KP-I #3 5-07-93	14.0
8:00am KP-I #1 5-12-93	3.0
8:10am KP-I #2 5-12-93	3.0
8:15am KP-I #3 5-12-93	22.0
8:20am KP-I #1 5-14-93	3.0
8:00am KP-I #3 5-14-93	1.0
7:35am KP-I #1 5-17-93	2.0
7:30am KP-I #2 5-17-93	6.0
7:25am KP-I #3 5-17-93	8.0
11:00am LF-I 4-26-93	8.0
11:00am LF-I 4-28-93	780.0
11:00am LF-I 4-30-93	1590.0
1:00am LF-I 5-05-93	26.0
1:00am LF-I 5-11-93	38.0
11:00am LF-I 5-12-93	184.0
11:00am LF-I 5-09-93	75.0
11:00am LF-I 5-07-93	24.0
11:00am LF-I 5-14-93	7.0
11:00am LF-I 5-16-93	3.0
11:05am KP-I #3 5-19-93	9.0
11:00am LF-I 5-20-93	31.0
3:00pm KP-I #3 5-21-93	18.0
11:00am LF-I 5-24-93	7.0

SVL ANALYTICAL

Client: ECHO BAY
Client Sample ID: LF-I
Sample Collection Date: 4/06/93 12:15 PM
Date of Sample Receipt: 04/09/93
Date of Report: 04/23/93

SVL Job Number: 30299
SVL Sample ID: W38813
Area:
Matrix: WATER

ANALYTE	RESULT	UNIT	DILN	M	ANALYTE	RESULT	UNIT	DILN	M
pH	7.90	units		W	Mercury	< .0002	mg/L		V
Aluminum	.95	mg/L		P	Molybdenum	.040	mg/L		P
Arsenic	< .04	mg/L		P	Nickel	.02	mg/L		P
Boron	.031	mg/L		P	Potassium	13.8	mg/L		P
Cadmium	< .002	mg/L		P	Selenium	< .04	mg/L		P
Calcium	126.	mg/L		P	Sodium	35.3	mg/L		P
Copper	.011	mg/L		P	Zinc	.038	mg/L		P
Iron	3.17	mg/L		P	Conductance	1430	umhos		
Lead	< .04	mg/L		P	TSS	91.4	mg/L		W
Magnesium	62.8	mg/L		P	Nitrate-N	70.5	mg/L		
Manganese	.112	mg/L		P					

M(ethods): P=ICP F=GFAA V=CVAA C=COLORIMETRIC I=ION CHROMATOGRAPHY L=LECO T=TITRATION W=WET CHEM E=ELECTRODE

CONDUCTIVITY RESULT WAS ADJUSTED TO 25 DEGREES C

THIS REPORT HAS BEEN CHECKED AND IS CERTIFIED TO BE ACCURATE:

DATE 04/26/93

TrecLen Laboratories

N. 1403 Greene St., Spokane, WA 99202 (509) 535-5501
P.O. Box 14642, Spokane, WA 99214

ANALYTICAL REPORT

Client: Echo Bay Exploration, Inc.
Kettle River Project
921 Fish Hatchery Rd
Republic, WA 99166
Attn: Walt Hunt

Report Number: E-1167

Sample ID	mg/l TSS
9:30am LF-I 3-17-93	156.0
:00am LF-I 3-19-93	37.0
:30am LF-I 3-22-93	3.0
7:40am LF-I 3-24-93	<1.0
7:40am LF-I 3-26-93	268.0
7:30am LF-I 3-29-93	1.0
7:40am LF-I 3-31-93	2.0
1:30pm LF-I 4-05-93	9.0
11:00am LF-I 4-07-93	23.0
9:00am LF-I 4-09-93	268.0
1:30pm LF-I 4-12-93	7080.0
11:00am LF-I 4-14-93	120.0
10:00am LF-I 4-16-93	384.0
2:30pm LF-I 4-20-93	156.0
2:30pm LF-I 4-21-93	124.0
2:30pm LF-I 4-23-93	192.0
12:15pm KPI-1 4-26-93	4.0
7:00am KPI-1 4-28-93	1.0
12:00pm KPI-1 4-30-93	8.0
8:00am KPI-1 5-03-93	1.0
8:15am KPI-2 5-03-93	<1.0

Date: May 10, 1993

Signed: Heather Mollan

APPENDIX C
GEOCHEMISTRY AND WATER QUALITY

APPENDIX C-1
GEOCHEMISTRY DATA
TABLES AND KINETIC TEST RESULTS

TABLE C-1a

SUMMARY OF WASTE/MINE WALL ROCK SAMPLES SUBMITTED FOR ACID BASE ACCOUNTING ANALYSIS

LFABA Number	Rock Type	Sample Location			Geologic Description
		Northing	Easting	Elevation	
1	Low Grade Ore	26142	7110	2655	Altered limestone, trace hematite, trace pyrite, disseminated and in microfractures.
2	Intrusive	26263	7098	2655	Biotite rhyodacite, propylitically altered, trace carbonate mineralization occurring in veinlets.
3	Clastic	26280	7224	2650	Clastic, silicic, trace pyrite in veinlets, and disseminations, trace carbonate mineralization.
4	Intrusive	26269	7203	2722	Biotite rhyodacite, minimal alteration, trace pyrite occurring in veinlets.
5	Low Grade Ore	26840	7140	2755	Altered limestone, trace hematite, trace magnetite, trace calcite, fractured.
6	Low Grade Ore	26900	7120	2615	Massive hematite and magnetite, trace carbonate mineralization, 2% pyrite in veinlets.
7	Clastic	27063	7184	2620	Clastic, silicic, 2-5% pyrite in veinlets and microfractures, some disseminations.
8	Low Grade Ore	27061	7166	2620	Altered limestone, 60% massive hematite and magnetite, trace sulfide mineralization.
9	Clastic	25945	7146	2730	Clastic, sharpstone, quartz veining with trace pyrite disseminated throughout.
10	Limestone	25944	7165	2730	Limestone, unaltered, weak microfracturing, trace sulfide mineralization consisting of disseminated pyrite.
11	Clastic	26912	7218	2745	Clastic, siltstone/sharpstone, minor quartz veining, 2-5% pyrite in veinlets and as disseminations.

Source: Golder 1993.

TABLE C-1b

SUMMARY OF DESCRIPTIVE CHARACTERISTICS WASTE/MINE WALL ROCK SAMPLES SUBMITTED FOR ACID BASE ACCOUNTING ANALYSIS

Sample #	Hole #	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
1	C-170	Clastic	335-360	26100	7220	2840	Pulp	East	Clastics, trace silica, 1% pyrite
2	C-138	Clastic	500-510	26100	7385	3010	Pulp	East	Clastics, trace silica, trace $CaCO_3$, 0.5 % pyrite, trace chalcopyrite
3	C-166	Clastic	181-186	26300	7367	3060	Pulp	East	Clastics, trace pyrite as blebs and tiny veinlets, trace silica
4	C-142	Clastic	475-480	26300	7335	2978	Pulp	East	Clastics, 2% pyrite with trace chalcopyrite in tiny quartz veinlets
5	C-147	Clastic	275-280	26500	7200	2922	Pulp	East	Clastics, 2% pyrite as veinlets, 1% magnetite as blebs, trace hematite, weak silicic
6	C-178	Clastic	118-123	26500	7325	3080	Pulp	East	Clastics, 3% pyrite quartz-calcite veinlets, trace chalcopyrite, weak silicic
7	C-100	Clastic	263-268	26700	7185	2995	Pulp	East	Clastics, 20% pyrite with 5% magnetite in quartz veinlets, weak silicic, very chloritic
8	C-066	Clastic	311.5-316.5	26700	7244	2845	Pulp	East	Clastics, 1% pyrite with 0.5% chalcopyrite in quartz veinlets, moderately chloritic
9	C-105	Clastic	186-191	26900	7163	2965	Pulp	East	Clastics, 3% pyrite as patchy clots, trace chalcopyrite with quartz veinlets
10	C-086	Clastic	255-260	26900	7209	2794	Pulp	East	Clastics, 2% pyrite with <1% chalcopyrite with quartz as veinlets, trace $CaCO_3$
11	C-085	Clastic	181.5-185	26900	7165	2910	Pulp	East	Clastics, 2% pyrite with trace chalcopyrite in quartz veinlets, very chloritic
12	C-102	Clastic	78-83	26900	7245	3050	Pulp	East	Clastics, 15% pyrite with trace chalcopyrite as veins, slightly chloritic
13	C-080	Clastic	90-95	27100	7135	2915	Pulp	East	Clastics, 3% pyrite with trace chalcopyrite in quartz veinlets
14	C-141	Clastic	345-350	27100	7160	2720	Pulp	East	Clastics, trace pyrite as tiny veinlets

TABLE C-1b
(Continued)

Sample #	Hole #	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
15	C-184	Clastic	384-389	27100	7177	2618	Pulp	East	Clastics, trace pyrite as disseminations
16	C-095	Clastic	280-285	27300	7071	2550	Pulp	East	Clastics, <5% pyrite, in quartz veinlets
17	C-096	Clastic	359-365	27350	7017	2437	Pulp	East	Clastics, <5% pyrite in quartz veinlets, slightly silicic
18	C-116	Clastic	247-252	27300	7130	2660	Pulp	East	Clastics, 5% pyrite with 2% chalcopyrite in quartz veinlets
19	C-151	Clastic	194.5-200	27500	6981	2605	Pulp	East	Clastics, 10% pyrite with trace chalcopyrite in quartz veinlets
20	C-149	Clastic	255-260	27500	6922	2514	Pulp	East	Clastics, 2% pyrite with quartz in stockworks and disseminated, trace $CaCO_3$
21	C-191	Intrusive	363-370	26200	7148	2723	Core	West	Biotite rhyodacite, propyllitic altered, trace $CaCO_3$ as veinlets
22	C-140	Limestone	380-387.5	26200	7247	2940	Core	West	Limestone, $CaCO_3$ veining, bleached
23	C-178	Low Grade Ore	78-80	26500	7287	3087	Core	West	Altered limestone, 4% pyrite, 10% magnetite, 1% pyrrhotite, 80% hematite, trace $CaCO_3$, slightly silicic
24	C-304	Intrusive	379-384	26400	7248	2790	Core	West	Hornblende, rhyodacite, trace pyrite, disseminated
25	C-089	Intrusive	344-350	26700	7255	2768	Core	West	Hornblende, rhyodacite, no mineralization
26	C-066	Limestone	248-254	26700	7180	2855	Core	West	Limestone, 2% pyrite as wispy masses, 8% magnetite as patches, minor $CaCO_3$
27	C-110	Intrusive	324-328	26950	7171	2650	Core	West	Altered rhyodacite, argillic
28	C-160	Low Grade Ore	353-358	26950	7126	2767	Core	West	Altered limestone, trace pyrite disseminations, 50% magnetite, 35% hematite, trace $CaCO_3$, silicic
29	C-127	Low Grade Ore	239.5-244	27150	7065	2743	Core	West	Altered limestone, trace pyrite, 2% magnetite, 40% hematite, weakly silicic
30	C-131	Limestone	262-266.5	27350	7038	2546	Core	West	Limestone, bleached, trace pyrite disseminated
31	C-145	Clastic	500-510	26400	7395	2970	Core	Dev.	Clastics, conglomerate, trace pyrite, trace chalcopyrite
32	C-307	Clastic	505-510	26400	7390	2845	Core	Dev.	Clastics, <2% pyrite

TABLE C-1b
(Continued)

Sample #	Hole #	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
33	C-147	Clastic	425-435	26500	7355	2930	Core	Dev.	Clastics, conglomerate, trace pyrite
34	C-178	Clastic	193-198	26500	7400	3065	Core	Dev.	Clastics, <1% pyrite
35	C-063	Clastic	361-366	26600	7340	2895	Core	Dev.	Clastics, conglomerate, trace pyrite
36	C-063	Clastic	416-421.5	26600	7395	2890	Core	Dev.	Clastics, conglomerate, trace pyrite
37	C-066	Clastic	431.5-437	26700	7295	2840	Core	Dev.	Clastics, trace pyrite
38	C-097	Clastic	351-355	26700	7230	2935	Core	Dev.	Clastics, 2% pyrite
39	C-030	Clastic	175-185	26700	7330	3005	Core	Dev.	Clastics, trace disseminated pyrite
40	C-069	Clastic	335-340	26800	7295	2880	Core	Dev.	Clastics, trace pyrite
41	C-329	Clastic	160-166	26800	7320	3027	Core	Dev.	Clastics, trace pyrite
42	C-368	Limestone	99-102	26070	7105	2925	Core	Dev.	Limestone, massive, "clean"
43	C-191	Intrusive	340-345	26200	7127	2739	Core	Dev.	Biotite rhyodacite, trace chlorite, pervasive calcite
44	2620U2	Intrusive	62-65	27300	7076	2695	Core	Int.	Altered rhyodacite (poss Thr), weak quartz-calcite veins
45	C-179	Intrusive	351-356	26800	7074	2648	Core	Dev.	Hornblende rhyodacite, moderate propyllitic alteration, weak calcite veins
46	C-27	Limestone	29-33	26300	7540	3352	Core	Dev.	Dense, fine-grained limestone, moderate calcite veins
47	C-321A	Limestone	20-23	26300	6877	2917	Core	Dev.	Fine-grained, crystalline limestone
48	C-321A	Limestone	27-30	26300	6883	2913	Core	Dev.	Fine-grained, crystalline limestone
49	C-27	Limestone	15-19	26300	7540	3366	Core	Dev.	Fine-grained limestone, moderate calcite veins
50	C-179	Intrusive	561-566	26800	7275	2589	Core	Dev.	Biotite rhyodacite, moderate propyllitic alteration, trace pyrite
51	C-327	Limestone	38-41	26400	6913	2887	Core	Dev.	Very fine-grained, grey limestone
52	C-327	Limestone	18-21	26400	6898	2901	Core	Dev.	Very fine-grained, grey limestone

TABLE C-1b
(Continued)

Sample #	Hole #	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
53	2620U5	Intrusive	12-16	27300	7111	2647	Core	Int.	Altered rhyodacite (poss Thr), weak quartz-calcite veins, trace pyrite
54	C-179	Intrusive	361-366	26800	7085	2645	Core	Dev.	Hornblende rhyodacite, moderately propyllitic alteration, weak calcite veins
55	LCH0903	Altered Limestone	2680 ACC#2	27090		2686	Chip		15% magnetite
56	LCO2190	Altered Limestone	2745-26950W	26950	7140	2750	Core		Weak magnetite replacement, 15% magnetite, 25% pyrite +po
57	LCO2240	Altered Limestone	2745-2700W	27000	7129	2750	Core		Partial magnetite replacement, 10% pyrite, as fracture fill
58	LCO2770	Altered Limestone	2615-27150W	27150	7116	2620	Core		30% magnetite as replacement, 3% pyrite on fractures
59	LCO2830	Altered Limestone	2615-26925W	26925	7153	2620	Core		Banded 5% magnetite, 2% disseminated pyrite
60	LCO3190	Altered Limestone	2830-26425W	26424	7180	2835	Core		Variable magnetite as matrix, 30% magnetite, 7% pyrite
61	LCO3210	Altered Limestone	2830-26400W	26400	7211	2835	Core		30% magnetite, trace hematite, 4% pyrite
62	LCO3250	Altered Limestone	2830-26350W	26349	7230	2835	Core		Weakly altered, 1% pyrite, 3% magnetite
63	LCO3270	Altered Limestone	2830-26300W	26300	7249	2835	Core		Variable magnetite as matrix, 4% magnetite, 2% pyrite
64	LCO4260	Altered Limestone	2875-26775W	26775	7159	2880	Core		Massive magnetite, 75% magnetite, 10% pyrite
65	LCO4280	Altered Limestone	2875-26825W	26825	7144	2880	Core		Discontinuous bands magnetite, 50% magnetite
66	LCO4340	Altered Limestone	2875-26875W	26875	7105	2880	Core		Massive hematite w/3% magnetite in bx fragments
67	LCO4500	Altered Limestone	2940-25975W	25975	7209	2945	Core		Unmineralized patches, 2% magnetite, 6% pyrite
68	LCO4520	Altered Limestone	2940-26000W	26000	7201	2945	Core		Local massive pyrite + chlorite, 8% magnetite, 30% pyrite
69	LCO4610	Altered Limestone	2940-26225W	26225	7243	2945	Core		Massive sulfide, 98% pyrite
70	LCH0901	Intrusive	2680 N Drift	27250	7090	2690	Chip		Propyllitically altered Thr, chloritic, trace pyrite, 5% $CaCO_3$ veins
71	LCH0902	Intrusive	2681 MB	27090	7180	2686	Chip		Fresh Thr, rose tint, trace $CaCO_3$ veinlets

TABLE C-1b
(Continued)

Sample #	Hole #	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
72	LCH0904	Intrusive	2680 N Drift	27000	7175	2685	Chip		Fresh Thr, 2% $CaCO_3$ veinlets
73	LCH0905	Intrusive	2680 N Drift	26920	7195	2684	Chip		Fresh Thr, rose tint, w/1% $CaCO_3$ veinlets
74	LCH0906	Intrusive	2680 N Drift	26915	7175	2684	Chip		Fresh Thr, rose tint, porphyrite, 2% $CaCO_3$ veinlets
75	LCH0908	Intrusive	2680 Ramp	26620	7190	2675	Chip		Lamprophyne dike, fresh
76	LCH0910	Intrusive	2615 ACC	26950	7070	2615	Chip		Fresh Thr
77	LCH0915	Intrusive	2745 N Drift	27300	7075	2760	Chip		Altered Thr in W margin, sericitic alteration
78	LCH0917	Intrusive	2830 N Drift	26730	7260	2835	Chip		Thr, argillic alteration
79	LCH0918	Intrusive	2830 S Drift	26150	7230	2835	Chip		Thr, argillic alteration, footwall 500 flt
80	LCH0920	Intrusive	2830 F Primary	26250	7330	2835	Chip		Thr, argillic alteration, footwall 500 flt
81	LCO2250	Intrusive	2745-27250W	27250	7085	2750	Core		Fresh, Thr, no mineralization
82	LCO2890	Intrusive	2615-26950W	26950	7146	2620	Core		Fresh, Thr, no mineralization
83	LCO5657	Intrusive	2875-26775E	26775	7196	2880	Core		Medium-grained Thr, plagioclase phenocrysts, no mineralization
84	LCO5658	Intrusive	2875-26725E	26725	7204	2880	Core		Fresh, Thr, no mineralization
85	LCH0907	Limestone	2680 ACC	26870	7130	2681	Chip		1% disseminated pyrite
86	LCH0909	Limestone	2680 Ramp	26580	7225	2670	Chip		Clean, re-crystallized
87	LCH0911	Limestone	2615 T-Bay	27020	7030	2620	Chip		Clean, micritic
88	LCH0912	Limestone	2717 WXC	26075	7100	2720	Chip		Bx'd, $CaCO_3$ matrix, 2% pyrite veinlets
89	LCH0913	Limestone	2745 ACC	26925	7050	2760	Chip		Clean, micritic
90	LCH0914	Limestone	2746 MB	27090	7040	2755	Chip		Clean, micritic
91	LCH0916	Limestone	2830 N Drift	26455	7250	2855	Chip		Bx'd, $CaCO_3$ matrix, trace disseminated pyrite
92	LCH0919	Limestone	2830 N Drift	26175	7225	2835	Chip		Clean, micritic

TABLE C-1b
(Concluded)

Sample #	Hole #	Rock	Core Interval	North	East	Elev. (ft)	Sample Type	Stope Wall	Description
93	LCH0921	Limestone	2875 SACC	26430	7180	2880	Chip		Bx'd, 2% disseminated pyrite
94	LCO3630	Limestone	2830-26175W	26175	7207	2835	Chip		Grey, unaltered, 1% pyrite in fractures
95	LCO4430	Limestone	2875-27050W	27050	7088	2880	Chip		Medium grey, clean, unaltered
96	LCO4570	Limestone	2940-26075W	26075	7223	2945	Core		Unaltered, $CaCO_3$ veinlets, pyrite veinlets, 2% pyrite
97	LCO4580	Limestone	2940-26100W	26100	7232	2945	Core		Weak calc veins w/sulfides on fractures, 1% pyrite
98	LCO5655	Limestone	2940-26300W	26300	7241	2945	Core		Grey, micritic, no mineralization
99	LCO5656	Limestone	2940-26450W	26450	7183	2940	Core		Clean, unaltered

Source: Revised from Golder 1993.

TABLE C-2

SUMMARY OF BACKFILL QUARRY SAMPLES SUBMITTED FOR ACID BASE ACCOUNTING ANALYSIS

Sample #	Bore Hole	Rock	Core Interval	North	East	Elev. (ft)	Sample Type
1	LR-1	Intrusive Biotite rhyodacite	0-20	27225	6530	2835	Drill Chip
2		Intrusive Biotite rhyodacite	20-40				Drill Chip
3		Intrusive Biotite rhyodacite	40-50				Drill Chip
4	LR-2	Intrusive Biotite rhyodacite	0-20	26740	6280	2875	Drill Chip
5		Intrusive Biotite rhyodacite	20-40				Drill Chip
6		Intrusive Biotite rhyodacite	40-60				Drill Chip
7		Clastic	60-80				Drill Chip
8		Clastic	80-100				Drill Chip
9		Clastic	100-120				Drill Chip
10		Clastic	120-140				Drill Chip
11		Clastic	140-160				Drill Chip
12		Clastic	160-180				Drill Chip
13		Clastic	180-200				Drill Chip
14		Clastic	200-220				Drill Chip
15	LR-3	Clastic	0-20	26000	6100	2800	Drill Chip
16		Clastic	20-40				Drill Chip
17		Clastic	40-60				Drill Chip
18		Clastic	60-80				Drill Chip
19		Clastic	80-100				Drill Chip
20		Clastic	100-120				Drill Chip

TABLE C-2
(Continued)

Sample #	Bore Hole	Rock	Core Interval	North	East	Elev. (ft)	Sample Type
21	LR-4	Overburden	0-10	27116	6351	2895	Drill Chip
22		Intrusive Biotite rhyodacite	10-20				Drill Chip
23		Intrusive Biotite rhyodacite	20-30				Drill Chip
24		Intrusive Biotite rhyodacite	30-40				Drill Chip
25		Intrusive Biotite rhyodacite	40-50				Drill Chip
26		Intrusive Biotite rhyodacite	50-60				Drill Chip
27		Intrusive Biotite rhyodacite	60-70				Drill Chip
28		Intrusive Biotite rhyodacite	70-80				Drill Chip
29		Clastic	80-90				Drill Chip
30		Clastic	90-100				Drill Chip
31		Clastic	100-110				Drill Chip
32		Intrusive Biotite rhyodacite	110-120				Drill Chip
33		Intrusive Biotite rhyodacite	120-130				Drill Chip
34		Intrusive Biotite rhyodacite	130-140				Drill Chip
35		Intrusive Biotite rhyodacite	140-150				Drill Chip

TABLE C-2
(Continued)

Sample #	Bore Hole	Rock	Core Interval	North	East	Elev. (ft)	Sample Type
36	LR-5	Overburden	0-10	26923	6310	2893	Drill Chip
37		Intrusive Biotite rhyodacite	10-20				Drill Chip
38		Intrusive Biotite rhyodacite	20-30				Drill Chip
39		Intrusive Biotite rhyodacite	30-40				Drill Chip
40		Intrusive Biotite rhyodacite	40-50				Drill Chip
41		Intrusive Biotite rhyodacite	50-60				Drill Chip
42		Clastic	60-70				Drill Chip
43		Clastic	70-80				Drill Chip
44		Clastic	80-90				Drill Chip
45		Clastic	90-100				Drill Chip
46		Clastic	100-110				Drill Chip
47		Clastic	110-120				Drill Chip
48		Clastic	120-130				Drill Chip
49		Clastic	130-140				Drill Chip

TABLE C-2
(Continued)

Sample #	Bore Hole	Rock	Core Interval	North	East	Elev. (ft)	Sample Type
50	LR-6	Clastic	0-10	26923	6315	2893	Drill Chip
51		Clastic	10-20				Drill Chip
52		Clastic	20-30				Drill Chip
53		Clastic	30-40				Drill Chip
54		Clastic	40-50				Drill Chip
55		Clastic	50-60				Drill Chip
56		Clastic	60-70				Drill Chip
57		Clastic	70-80				Drill Chip
58		Clastic	80-90				Drill Chip
59		Clastic	90-100				Drill Chip
60		Clastic	100-110				Drill Chip
61		Clastic	110-120				Drill Chip
62		Intrusive Biotite rhyodacite	120-130				Drill Chip
63		Intrusive Biotite rhyodacite	130-140				Drill Chip
64		Intrusive Biotite rhyodacite	140-150				Drill Chip
65		Intrusive Biotite rhyodacite	150-160				Drill Chip
66		Intrusive Biotite rhyodacite	160-170				Drill Chip
67		Clastic	170-180				Drill Chip
68		Clastic	180-190				Drill Chip
69		Clastic	190-200				Drill Chip
70		Intrusive Biotite rhyodacite	200-210				Drill Chip
71		Clastic	210-220				Drill Chip
72		Clastic	220-230				Drill Chip
73		Clastic	230-240				Drill Chip
74		Clastic	240-250				Drill Chip
75		Clastic	250-260				Drill Chip

TABLE C-2
(Continued)

Sample #	Bore Hole	Rock	Core Interval	North	East	Elev. (ft)	Sample Type
76	LR-7	Clastic	0-10	26146	6120	2827	Drill Chip
77		Clastic	10-20				Drill Chip
78		Clastic	20-30				Drill Chip
79		Clastic	30-40				Drill Chip
80		Clastic	40-50				Drill Chip
81		Clastic	50-60				Drill Chip
82		Clastic	60-70				Drill Chip
83		Clastic	70-80				Drill Chip
84		Clastic	80-90				Drill Chip
85		Clastic	90-100				Drill Chip
86		Clastic	100-110				Drill Chip
87		Clastic	110-120				Drill Chip
88		Clastic	120-130				Drill Chip
89		Clastic	130-140				Drill Chip
90		Clastic	140-150				Drill Chip
91		Clastic	150-160				Drill Chip
92		Clastic	160-170				Drill Chip
93		Clastic	170-180				Drill Chip
94		Clastic	180-190				Drill Chip
95		Clastic	190-200				Drill Chip
96		Clastic	200-210				Drill Chip

TABLE C-2
(Continued)

Sample #	Bore Hole	Rock	Core Interval	North	East	Elev. (ft)	Sample Type
97	LR-8	Clastic	0-10	26354	6144	2813	Drill Chip
98		Clastic	10-20				Drill Chip
99		Clastic	20-30				Drill Chip
100		Clastic	30-40				Drill Chip
101		Clastic	40-50				Drill Chip
102		Clastic	50-60				Drill Chip
103		Clastic	60-70				Drill Chip
104		Clastic	70-80				Drill Chip
105		Clastic	80-90				Drill Chip
106		Clastic	90-100				Drill Chip
107	LR-9	Clastic	0-10	26353	6146	2814	Drill Chip
108		Clastic	10-20				Drill Chip
109		Clastic	20-30				Drill Chip
110		Clastic	30-40				Drill Chip
111		Clastic	40-50				Drill Chip
112		Clastic	50-60				Drill Chip
113		Clastic	60-70				Drill Chip
114		Intrusive - Hornblende or altered	70-80				Drill Chip
115		Clastic	80-90				Drill Chip
116		Clastic	90-100				Drill Chip
117		Clastic	100-110				Drill Chip
118		Clastic	110-120				Drill Chip
119		Clastic	120-130				Drill Chip
120		Clastic	130-140				Drill Chip

TABLE C-2
(Concluded)

Sample #	Bore Hole	Rock	Core Interval	North	East	Elev. (ft)	Sample Type
121	LR-10	Clastic	0-10	26475	6181	2824	Drill Chip
122		Clastic	10-20				Drill Chip
123		Clastic	20-30				Drill Chip
124		Clastic	30-40				Drill Chip
125		Clastic	40-50				Drill Chip
126		Clastic	50-60				Drill Chip
127		Clastic	60-70				Drill Chip
128		Clastic	70-80				Drill Chip
129		Clastic	80-90				Drill Chip
130		Clastic	90-100				Drill Chip
131	LR-11	Clastic	0-10	26475	6184	2825	Drill Chip
132		Clastic	10-20				Drill Chip
133		Clastic	20-30				Drill Chip
134		Clastic	30-40				Drill Chip
135		Clastic	40-50				Drill Chip
136		Clastic	50-60				Drill Chip
137		Clastic	60-70				Drill Chip
138		Clastic	70-80				Drill Chip
139		Clastic	80-90				Drill Chip
140		Clastic	90-100				Drill Chip
141		Clastic	100-110				Drill Chip
142		Clastic	110-120				Drill Chip
143		Clastic	120-130				Drill Chip
144		Clastic	130-140				Drill Chip
145		Clastic	140-150				Drill Chip

Source: Revised from Golder 1993.

TABLE C-3

ACID-BASE ACCOUNTING RESULTS OF WASTE/MINE WALL ROCK SAMPLES

Sample #	Sample Name	Sample Lithology	Total Sulfur (%)	AGP[1] (TCaCO3/kT)[4]	ANP[2] (TCaCO3/kT)	NNP[3] (TCaCO3/kT)	ANP:AGP RATIO
1	LFABA #1	Low Grade Ore	0.02	0.6	475	474.4	791.6
2	LFABA #2	Intrusive	1.00	31.2	332	300.8	10.6
3	LFABA #3	Clastic	2.79	87.2	51.6	-35.6	0.59
4	LFABA #4	Intrusive	0.42	13.1	177	163.9	13.51
5	LFABA #5	Low Grade Ore	0.01	0.3	439	438.7	1,463
6	LFABA #6	Low Grade Ore	1.65	51.6	434	382	8.41
7	LFABA #7	Clastic	0.72	22.5	72.8	50.3	3.23
8	LFABA #8	Low Grade Ore	0.82	25.6	210	184.4	8.20
9	LFABA #9	Clastic	3.08	96.2	68.0	-28.2	0.70
10	LFABA #10	Limestone	1.89	59.1	464	404.9	7.85
11	LFABA #11	Clastic	7.03	220	61.9	-158.1	0.28
12	91-LFC-170	Clastic	2.02	63.1	55.2	-7.9	0.9
13	91-LFC-138	Clastic	3.65	114.1	11.6	-102.5	0.1
14	91-LFC-166	Clastic	5.45	170.3	67.5	-102.8	0.4
15	91-LFC-142	Clastic	2.1	65.6	28.8	-36.8	0.4
16	91-LFC-147	Clastic	4.31	134.7	109	-25.7	0.8
17	91-LFC-178	Clastic	6.88	215.0	47.2	-167.8	0.2
18	91-LFC-100	Clastic	8.11	253.4	28.6	-224.8	0.1
19	91-LFC-105	Clastic	2.5	78.1	74.6	-3.5	1.0
20	91-LFC-086	Clastic	2.77	86.6	336	249.4	3.9

TABLE C-3
(Continued)

Sample #	Sample Name	Sample Lithology	Total Sulfur (%)	AGP[1] (TCaCO3/kT)[4]	ANP[2] (TCaCO3/kT)	NNP[3] (TCaCO3/kT)	ANP:AGP RATIO
21	91-LFC-085	Clastic	7.29	227.8	168	-59.8	0.7
22	91-LFC-102	Clastic	8.4	262.5	141	-121.5	0.5
23	91-LFC-080	Clastic	2.21	69.1	63.6	-5.5	0.9
24	91-LFC-141	Clastic	5.64	176.3	22.2	-154.1	0.1
25	91-LFC-184	Clastic	2.95	92.2	52.9	-39.3	0.6
26	91-LFC-95	Clastic	5.21	162.8	88.7	-74.1	0.5
27	91-LFC-96	Clastic	2.55	79.7	114	34.3	1.4
28	91-LFC-116	Clastic	8.29	259.1	9.6	-249.5	0.0
29	91-LFC-151	Clastic	6.95	217.2	86.5	-130.7	0.4
30	91-LFC-149	Clastic	3.25	101.6	77.1	-24.5	0.8
31	91-LFC-066	Clastic	2.57	80.3	69.6	-10.7	0.9
32	91-LFC-191	Intrusive	0.15	4.7	227	222.3	48.3
33	91-LFC-140	Limestone	0.20	6.2	1020	1014	164.5
34	91-LFC-178	Low Grade Ore	4.17	130	429	299	3.3
35	91-LFC-304	Intrusive	1.20	37.5	252	194.5	6.2
36	91-LFC-089	Intrusive	0.12	3.8	308	304.2	81.0
37	91-LFC-066	Limestone	0.51	15.9	791	775.1	49.7
38	91-LFC-110	Intrusive	0.06	1.9	207	205.1	108.9
39	91-LFC-160	Low Grade Ore	0.21	6.6	596	589.4	90.3
40	91-LFC-127	Low Grade Ore	0.21	6.6	639	96.8	96.8
41	91-LFC-131	Limestone	0.13	4.1	1020	1015.9	248.7
42	91-LFC-145	Clastic	1.32	41.2	108.0	66.8	2.6

TABLE C-3
(Continued)

Sample #	Sample Name	Sample Lithology	Total Sulfur (%)	AGP[1] (TCaCO3/kT)[4]	ANP[2] (TCaCO3/kT)	NNP[3] (TCaCO3/kT)	ANP:AGP RATIO
43	91-LFC-307	Clastic	0.26	8.1	94.1	86.0	11.6
44	91-LFC-147	Clastic	0.38	11.9	68.6	56.7	5.8
45	91-LFC-178	Clastic	0.97	30.3	103.0	72.7	3.4
46	91-LFC-063	Clastic	0.72	22.5	99.8	77.3	4.4
47	91-LFC-063	Clastic	0.11	3.4	57.2	53.8	16.8
48	91-LFC-066	Clastic	0.34	10.6	111.0	100.4	10.5
49	91-LFC-097	Clastic	2.92	91.2	57.2	-34.0	0.6
50	91-LFC-030	Clastic	3.28	102.0	85.0	-17.0	0.8
51	91-LFC-069	Clastic	1.14	35.6	111.0	75.4	3.1
52	91-LFC-329	Clastic	0.63	19.7	68.6	48.9	3.5
53	91-LFC-368	Limestone	0.07	2.2	2260.0	2257.8	1027.3
54	C-191	Intrusive	0.07	2.2	189.0	186.8	85.9
55	2620U2	Intrusive	0.10	3.1	189.0	185.9	61.0
56	C-179	Intrusive	0.21	6.6	157.0	150.4	23.8
57	C-27	Limestone	<.01	<0.3	1050.0	1050.0	3500.0
58	C-321A	Limestone	<.01	<0.3	1050.0	1050.0	3500.0
59	C-321A	Limestone	0.01	0.3	1050.0	1049.7	3500.0
60	C-27	Limestone	<.01	<0.3	1030.0	1030.0	3430.0
61	C-179	Intrusive	0.21	6.6	240.0	233.4	36.4
62	C-327	Limestone	0.03	0.9	1060.0	1059.1	1177.8
63	C-327	Limestone	0.01	0.3	1050.0	1049.7	3500.0
64	2620U5	Intrusive	0.30	9.4	137.0	127.6	14.6

TABLE C-3
(Continued)

Sample #	Sample Name	Sample Lithology	Total Sulfur (%)	AGP[1] (TCaCO3/kT)[4]	ANP[2] (TCaCO3/kT)	NNP[3] (TCaCO3/kT)	ANP:AGP RATIO
65	C-179	Intrusive	0.06	1.9	154.0	152.1	81.1
66	LCH0903	Altered Limestone	0.92	28.8	559	530.2	19.41
67	LC02190	Altered Limestone	5.87	183	557	374	3.04
68	LC02240	Altered Limestone	8.82	276	445	169	1.61
69	LC02770	Altered Limestone	5.21	163	524	361	3.21
70	LC02830	Altered Limestone	0.14	4.4	717	712.6	162.95
71	LC03190	Altered Limestone	5.99	187	580	393	3.10
72	LC03210	Altered Limestone	0.24	7.5	467	459.5	62.27
73	LC03250	Altered Limestone	0.75	23.4	625	601.6	26.71
74	LC03270	Altered Limestone	0.52	16.2	465	448.8	28.70
75	LC04260	Altered Limestone	5.35	167	292	125	1.75
76	LC04280	Altered Limestone	0.2	6.2	382	375.8	61.61
77	LC04340	Altered Limestone	0.83	25.9	455	429.1	17.57
78	LC04500	Altered Limestone	4.34	136	862	726	6.34
79	LC4520	Altered Limestone	8.3	259	550	291	2.12
80	LC04610	Altered Limestone	28.7	897	419	-478	0.47
81	LCH0901	Intrusive	0.48	15	174	159	11.60
82	LCH0902	Intrusive	0.02	0.6	122	121.4	203.33
83	LCH0904	Intrusive	<0.01	<0.3	495	≥494.7	≥1650.0
84	LCH0905	Intrusive	<0.01	<0.3	117	≥116.7	≥390.00
85	LCH0906	Intrusive	<0.01	<0.3	85.8	≥85.5	≥286.00
86	LCH0908	Intrusive	0.32	10	385	375	38.5

TABLE C-3
(Continued)

Sample #	Sample Name	Sample Lithology	Total Sulfur (%)	AGP[1] (TCaCO3/kT)[4]	ANP[2] (TCaCO3/kT)	NNP[3] (TCaCO3/kT)	ANP:AGP RATIO
87	LCH0910	Intrusive	0.03	0.9	85.8	84.9	95.33
88	LCH0915	Intrusive	0.14	4.4	114	109.6	25.91
89	LCH0917	Intrusive	0.03	0.9	347	346.1	385.56
90	LCH0918	Intrusive	0.18	5.6	124	118.4	22.14
91	LCH0920	Intrusive	0.31	9.7	194	184.3	20.00
92	LCO2250	Intrusive	0.14	4.4	102	97.6	23.18
93	LC02890	Intrusive	0.03	0.9	152	151.1	165.89
94	LC05657	Intrusive	0.23	7.2	102	94.8	14.7
95	LC05658	Intrusive	0.27	8.4	142	133.6	16.90
96	LCH0907	Limestone	0.67	20.9	847	826.1	40.53
97	LCH0909	Limestone	<0.1	<0.3	1020	≥1019.7	≥3400.0
98	LCH0911	Limestone	0.11	3.4	984	980.6	289.41
99	LCH0912	Limestone	3.87	121	797	676	6.59
100	LCH0913	Limestone	0.05	1.6	997	995.4	623.13
101	LCH0914	Limestone	0.02	0.6	982	981.4	1636.67
102	LCH0916	Limestone	0.07	2.2	430	427.8	195.45
103	LCH0919	Limestone	1.27	39.7	935	895.3	23.55
104	LCH0921	Limestone	0.03	0.9	633	632.1	703.33
105	LC03630	Limestone	0.23	7.2	975	967.8	135.42
106	LC04430	Limestone	0.22	6.9	681	674.1	98.70
107	LC04570	Limestone	0.37	11.6	1210	1198.4	104.31
108	LC04580	Limestone	0.37	11.6	1220	1208.4	105.17

TABLE C-3
(Concluded)

Sample #	Sample Name	Sample Lithology	Total Sulfur (%)	AGP[1] (TCaCO3/kT)[4]	ANP[2] (TCaCO3/kT)	NNP[3] (TCaCO3/kT)	ANP:AGP RATIO
109	LCO5655	Limestone	0.58	18.1	875	856.9	48.34
110	LC05656	Limestone	0.8	25	1310	1285	52.40

Revised from Golder 1993.

1 - Acid generation potential
2 - Acid neutralizing potential
3 - Net neutralizing potential
4 - Acid generating potential per kiloton

TABLE C-4

ACID BASE ACCOUNTING DATA LAMEFOOT QUARRY BACKFILL MATERIAL

Bore Hole	Depth Interval (fbgs)[1]	Total Sulfur %	AGP[1] $TCaCO_3$/kT[4]	ANP[2] $TCaCO_3$/kT	NNP[3] $TCaCO_3$/kT	ANP:AGP
LR-1	0-20	0.096	3	37	34	12.3
	20-40	<0.01	<0.01	67	67	≥67
	40-50	<0.01	<0.01	66	66	≥66
LR-2	0-20	<0.01	<0.01	51	51	≥51
	20-40	<0.01	<0.01	45	45	≥45
	40-60	0.22	7	61	54	7.7
	60-80	0.51	16	43	27	2.7
	80-100	1.44	45	44	-1	0.98
	100-120	2.81	88	43	-45	0.48
	120-140	0.70	22	20	-2	0.90
	140-160	1.95	61	67	6	1.09
	160-180	0.29	9	25	10	1.56
	180-200	0.93	29	71	42	2.45
	200-220	0.99	31	81	50	2.61
LR-3	0-20	0.25	8	33	25	4.12
	20-40	0.54	17	47	30	2.76
	40-60	0.93	29	69	40	2.37
	60-80	0.32	10	53	43	5.3
	80-100	0.38	12	50	38	4.16
	100-120	0.42	13	50	37	3.84

TABLE C-4
(Continued)

Bore Hole	Depth Interval (fbgs)[1]	Total Sulfur %	AGP[1] TCaCO$_3$/kT[4]	ANP[2] TCaCO$_3$/kT	NNP[3] TCaCO$_3$/kT	ANP:AGP
LR-4	0-10	0.11	3.4	6.1	2.7	1.79
	10-20	0.40	12.5	164.0	151.5	13.12
	20-30	0.13	4.1	166.0	161.9	40.49
	30-40	0.03	0.9	174.0	173.1	193
	40-50	<0.01	<0.3	166.0	≥165.7	≥553
	50-60	0.01	0.3	118.0	117.7	393
	60-70	1.17	36.6	88.4	51.8	2.42
	70-80	0.05	1.6	384.0	382.4	240
	80-90	0.36	11.2	86.1	74.9	7.69
	90-100	0.83	25.9	59.2	33.3	2.29
	100-110	1.09	34.1	111.0	76.9	3.26
	110-120	0.01	0.3	140.0	139.7	467
	120-130	0.02	0.6	140.0	139.4	233
	130-140	0.02	0.6	120.0	119.4	200
	140-150	0.04	1.2	92.7	91.5	77
LR-5	0-10	0.05	1.6	65.5	63.9	40.94
	10-20	0.03	0.9	112.0	111.1	124
	20-30	<0.01	<0.3	112.0	≥111.7	≥373
	30-40	<0.01	<0.3	144.0	≥143.7	≥480
	40-50	<0.01	<0.3	112.0	≥111.7	≥373
	50-60	0.03	0.9	159.0	158.1	177
	60-70	0.30	9.4	166.0	156.6	17.7
	70-80	0.93	29.1	105.0	75.9	3.61
	80-90	6.06	189.0	168.0	-21	0.89
	90-100	1.58	49.4	33.7	-15.7	0.68
	100-110	2.06	64.4	129.0	64.6	2.00
	110-120	2.56	80.0	156.0	76	1.95
	120-130	1.50	46.9	151.0	104.1	3.22
	130-140	2.92	91.2	129.0	37.8	1.41

TABLE C-4
(Continued)

Bore Hole	Depth Interval (fbgs)[1]	Total Sulfur %	AGP[1] $TCaCO_3/kT$[4]	ANP[2] $TCaCO_3/kT$	NNP[3] $TCaCO_3/kT$	ANP:AGP
LR-6	0-10	0.24	7.5	4.4	-3.1	0.59
	10-20	0.81	25.3	2.8	-22.5	0.11
	20-30	0.56	17.5	19.3	1.8	1.10
	30-40	0.73	22.8	42.8	20	1.88
	40-50	0.80	25.0	160.0	135	6.40
	50-60	1.15	35.9	129.0	93.1	3.59
	60-70	1.36	42.5	130.0	87.5	3.06
	70-80	3.07	95.9	137.0	41.1	1.43
	80-90	1.45	45.3	62.9	17.6	1.39
	90-100	2.90	90.6	43.2	-47.4	0.48
	100-110	2.79	87.2	82.5	-4.7	0.95
	110-120	0.79	24.7	149.0	124.3	6.03
	120-130	0.06	1.9	172.0	170.1	90.5
	130-140	0.06	1.9	167.0	165.1	87.9
	140-150	0.03	0.9	175.0	174.1	194
	150-160	0.30	9.4	175.0	165.6	18.62
	160-170	0.17	5.3	111.0	105.7	20.94
	170-180	1.15	35.9	89.9	54	2.50
	180-190	1.49	46.6	108.0	61.4	2.32
	190-200	1.18	36.9	114.0	77.1	3.09
	200-210	0.83	25.9	170.0	144.1	6.56
	210-220	0.55	17.2	126.0	108.8	7.33
	220-230	0.50	15.6	167.0	151.4	10.7
	230-240	0.65	20.3	91.3	71	4.50
	240-250	0.61	19.1	95.6	76.5	5.01
	250-260	0.85	26.6	87.0	60.4	3.27

TABLE C-4
(Continued)

Bore Hole	Depth Interval (fbgs)[1]	Total Sulfur %	AGP[1] TCaCO$_3$/kT[4]	ANP[2] TCaCO$_3$/kT	NNP[3] TCaCO$_3$/kT	ANP:AGP
LR-7	0-10	0.70	21.9	4.2	-17.7	0.19
	10-20	1.02	31.9	7.9	-24	0.25
	20-30	1.79	55.9	49.9	-6	0.89
	30-40	1.98	61.9	84.2	22.3	1.36
	40-50	1.66	51.9	71.3	19.4	1.37
	50-60	0.34	10.6	37.1	26.5	3.50
	60-70	0.75	23.4	178.0	154.6	7.61
	70-80	0.39	12.2	130.0	117.8	10.7
	80-90	0.43	13.4	37.7	24.3	2.81
	90-100	0.23	7.2	153.0	145.8	21.3
	100-110	2.02	63.1	151.0	87.9	2.39
	110-120	0.39	12.2	159.0	146.8	13.03
	120-130	0.17	5.3	0.1	-5.2	0.02
	130-140	0.65	20.3	121.0	100.7	5.95
	140-150	0.72	22.5	126.0	103.5	5.60
	150-160	0.64	20.0	129.0	109	6.45
	160-170	1.04	32.5	128.0	95.5	3.94
	170-180	0.89	27.8	102.0	74.2	3.67
	180-190	0.45	14.1	122.0	107.9	8.65
	190-200	1.35	42.2	99.4	57.2	2.36
	200-210	0.49	15.3	133.0	117.7	8.69
LR-8	0-10	0.82	25.6	44.6	19	1.74
	10-20	0.29	9.1	34.1	25	3.75
	20-30	0.15	4.7	42.0	37.3	8.94
	30-40	0.15	4.7	70.7	66	15.0
	40-50	0.27	8.4	83.8	75.4	9.98
	50-60	0.04	1.2	90.2	89	75.2
	60-70	0.10	3.1	159.0	155.9	51.3
	70-80	0.60	18.8	144.0	125.2	7.66
	80-90	1.77	55.3	160.0	104.7	2.89
	90-100	2.91	90.9	116.0	25.1	1.28

TABLE C-4
(Continued)

Bore Hole	Depth Interval (fbgs)[1]	Total Sulfur %	AGP[1] $TCaCO_3$/kT[4]	ANP[2] $TCaCO_3$/kT	NNP[3] $TCaCO_3$/kT	ANP:AGP
LR-9	0-10	0.11	3.4	38.0	34.6	11.18
	10-20	0.05	1.6	43.2	41.6	27.00
	20-30	0.18	5.6	52.4	46.8	9.36
	30-40	0.55	17.2	77.3	60.1	4.49
	40-50	1.50	46.9	147.0	100.1	3.13
	50-60	2.47	77.2	117.0	39.8	1.52
	60-70	5.72	179.0	151.0	-28	0.84
	70-80	5.50	172.0	148.0	-24	0.86
	80-90	4.86	152.0	101.0	-51	0.66
	90-100	4.87	152.0	83.4	-68.6	0.55
	100-110	1.34	41.9	27.1	-14.8	0.65
	110-120	1.81	56.6	78.0	21.4	1.38
	120-130	0.95	29.7	117.0	87.3	3.94
	130-140	0.80	25.0	129.0	104	5.16
LR-10	0-10	0.09	2.8	36.7	33.9	13.11
	10-20	0.21	6.6	26.3	19.7	3.98
	20-30	1.98	61.9	65.5	3.6	1.06
	30-40	0.64	20.0	15.5	-4.5	0.78
	40-50	0.53	16.6	51.1	34.5	3.08
	50-60	0.69	21.6	62.5	40.9	2.89
	60-70	0.73	22.8	99.4	76.6	4.36
	70-80	1.00	31.2	86.4	55.2	2.77
	80-90	0.56	17.5	60.2	42.7	3.44
	90-100	0.63	19.7	68.1	48.4	3.46

TABLE C-4
(Concluded)

Bore Hole	Depth Interval (fbgs)[1]	Total Sulfur %	AGP[1] $TCaCO_3$/kT[4]	ANP[2] $TCaCO_3$/kT	NNP[3] $TCaCO_3$/kT	ANP:AGP
LR-11	0-10	0.31	9.7	26.3	16.6	2.71
	10-20	0.75	23.4	49.8	26.4	2.13
	20-30	1.10	34.4	34.1	-0.3	0.99
	30-40	0.49	15.3	34.1	18.8	2.23
	40-50	1.36	42.5	57.6	15.1	1.36
	50-60	1.07	33.4	44.6	11.2	1.34
	60-70	0.58	18.1	52.4	34.3	2.90
	70-80	0.01	0.3	18.4	18.1	61.3
	80-90	1.02	31.9	120.0	88.1	3.76
	90-100	0.70	21.9	86.4	64.5	3.95
	100-110	0.96	30.0	123.0	93	4.10
	110-120	1.51	47.2	91.7	44.5	1.94
	120-130	0.96	30.0	107.0	77	3.57
	130-140	0.94	29.4	99.6	70.2	3.39
	140-150	1.35	42.2	119.0	76.8	2.82

Source: Revised from Golder 1993.

Note: [1]fbgs = Feet Below Ground Surface
0 - 10 feet is overburden

1 - Acid generating potential
2 - Acid neutralizing potential
3 - Net neutralization potential
4 - Acid generating potential per kiloton

TABLE C-5

ABA RESULTS FOR THE BACKFILL QUARRY SAMPLES RELATIVE TO THE EVALUATION CRITERIA

Geochemical Classification (See Table 3.3-3, FEISS)	Evaluation Criteria	
	NNP[1]	ANP[2]:AGP[3]
Group 1 Strong Acid Generation Potential	LR-2 (100-120) LR-5 (80-90) LR-6 (10-20) LR-6 (90-100) LR-7 (10-20) LR-9 (60-70) LR-9 (70-80) LR-9 (80-90) LR-9 (90-100)	LR-2 (80-100) LR-2 (100-120) LR-2 (120-140) LR-5 (80-90) LR-5 (90-100) LR-6 (0-10) LR-6 (10-20) LR-6 (90-100) LR-6 (100-110) LR-7 (0-10) LR-7 (10-20) LR-7 (20-30) LR-7 (120-130) LR-9 (60-70) LR-9 (70-80) LR-9 (80-90) LR-9 (90-100) LR-9 (100-110) LR-10 (30-40) LR-11 (20-30)
Group 2 Uncertain Acid Generation Potential	LR-2 (80-100) LR-2 (120-140) LR-2 (140-160) LR-2 (160-180) LR-4 (0-10) LR-5 (90-100) LR-6 (0-10)	LR-2 (60-80) LR-2 (140-160) LR-2 (160-180) LR-2 (180-200) LR-2 (200-220) LR-3 (20-40) LR-3 (40-60)

TABLE C-5
(Continued)

Geochemical Classification (See Table 3.3-3, FEISS)	Evaluation Criteria	
	NNP[1]	ANP[2]:AGP[3]
Group 2 (Cont.)	LR-6 (20-30)	LR-4 (0-10)
	LR-6 (30-40)	LR-4 (60-70)
	LR-6 (80-90)	LR-4 (90-100)
	LR-6 (100-110)	LR-5 (100-110)
	LR-7 (0-10)	LR-5 (110-120)
	LR-7 (20-30)	LR-5 (130-140)
	LR-7 (120-130)	LR-6 (20-30)
	LR-8 (0-10)	LR-6 (30-40)
	LR-9 (100-110)	LR-6 (70-80)
	LR-10 (20-30)	LR-6 (80-90)
	LR-10 (30-40)	LR-6 (170-180)
	LR-11 (20-30)	LR-6 (180-190)
	LR-11 (30-40)	LR-7 (30-40)
	LR-11 (40-50)	LR-7 (40-50)
	LR-11 (50-60)	LR-7 (80-90)
		LR-7 (100-110)
		LR-7 (190-200)
		LR-8 (0-10)
		LR-8 (80-90)
		LR-8 (90-100)
		LR-9 (50-60)
		LR-9 (110-120)
		LR-10 (20-30)
		LR-10 (50-60)
		LR-10 (70-80)
		LR-11 (0-10)
		LR-11 (10-20)
		LR-11 (30-40)
		LR-11 (40-50)
		LR-11 (50-60)
		LR-11 (60-70)
		LR-11 (110-120)
		LR-11 (140-150)

TABLE C-5
(Continued)

Geochemical Classification (See Table 3.3-3, FEISS)	Evaluation Criteria	
	NNP[1]	ANP[2]:AGP[3]
Group 3 Low Acid Generation Potential	LR-1 (0-20)	All LR-1 Samples
	LR-1 (20-40)	LR-2 (0-20)
	LR-1 (40-50)	LR-2 (20-40)
	LR-2 (0-20)	LR-2 (40-60)
	LR-2 (20-40)	LR-3 (0-20)
	LR-2 (40-60)	LR-3 (60-80)
	LR-2 (60-80)	LR-3 (80-100)
	LR-2 (180-200)	LR-3 (100-120)
	LR-2 (200-220)	LR-4 (10-20)
	All LR-3 Samples	LR-4 (20-30)
	LR-4 (10-20)	LR-4 (30-40)
	LR-4 (20-30)	LR-4 (40-50)
	LR-4 (30-40)	LR-4 (50-60)
	LR-4 (40-50)	LR-4 (70-80)
	LR-4 (50-60)	LR-4 (80-90)
	LR-4 (60-70)	LR-4 (100-110)
	LR-4 (70-80)	LR-4 (110-120)
	LR-4 (80-90)	LR-4 (120-130)
	LR-4 (90-100)	LR-4 (130-140)
	LR-4 (100-110)	LR-4 (140-150)
	LR-4 (110-120)	LR-5 (0-10)
	LR-4 (120-130)	LR-5 (10-20)
	LR-4 (130-140)	LR-5 (20-30)
	LR-4 (140-150)	LR-5 (30-40)
	LR-5 (0-10)	LR-5 (40-50)
	LR-5 (10-20)	LR-5 (50-60)
	LR-5 (20-30)	LR-5 (60-70)
	LR-5 (30-40)	LR-5 (70-80)
	LR-5 (40-50)	LR-5 (120-130)
	LR-5 (50-60)	LR-6 (40-50)
	LR-5 (60-70)	LR-6 (50-60)
	LR-5 (70-80)	LR-6 (60-70)
	LR-5 (100-110)	LR-6 (110-120)
	LR-5 (110-120)	LR-6 (120-130)
	LR-5 (120-130)	LR-6 (130-140)
	LR-5 (130-140)	

TABLE C-5
(Continued)

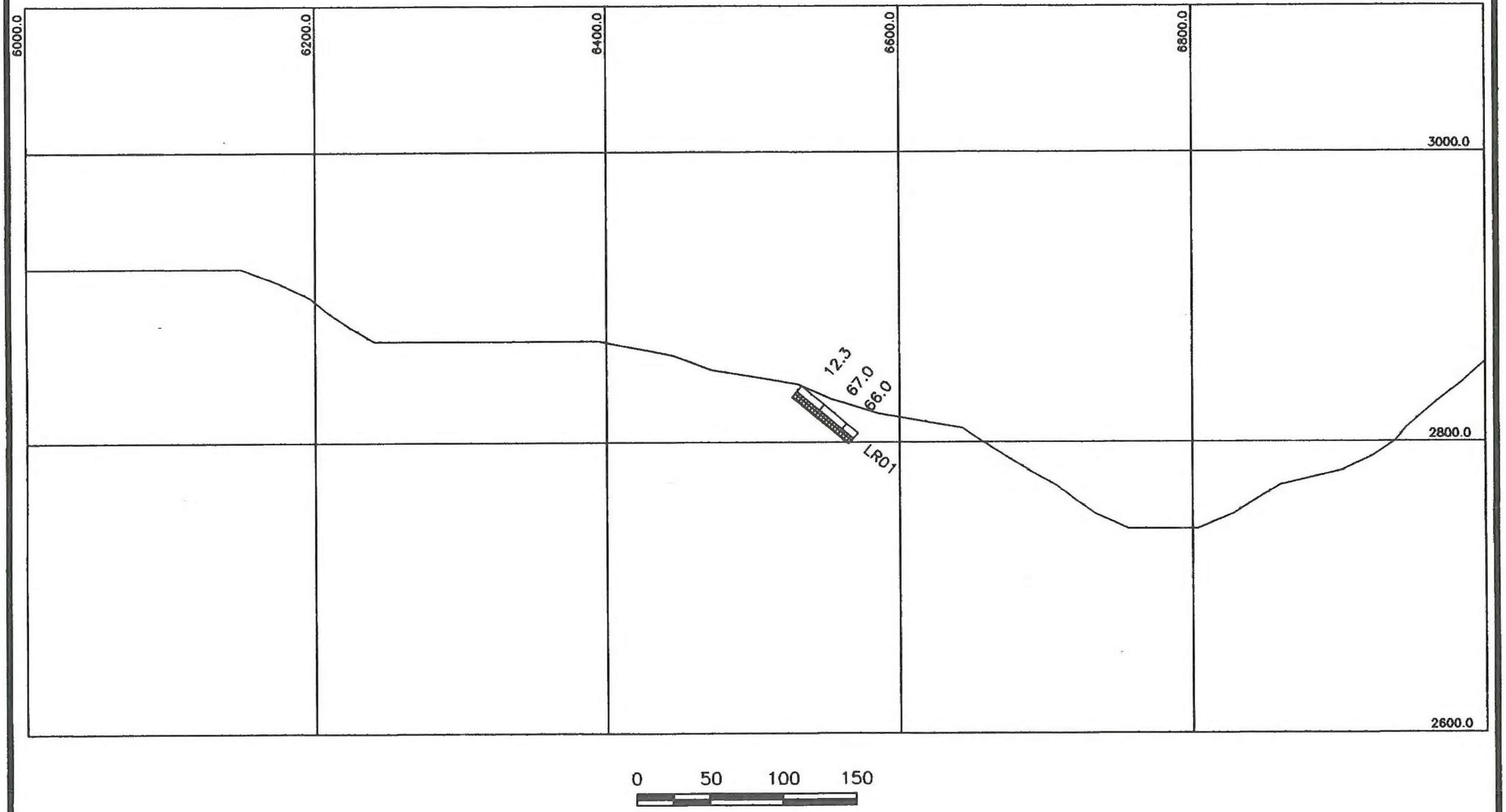
Geochemical Classification (See Table 3.3-3, FEISS)	Evaluation Criteria	
	NNP[1]	ANP[2]:AGP[3]
Group 3 (Cont.)	LR-6 (40-50)	LR-6 (140-150)
	LR-6 (50-60)	LR-6 (150-160)
	LR-6 (60-70)	LR-6 (160-170)
	LR-6 (70-80)	LR-6 (190-200)
	LR-6 (110-120)	LR-6 (200-210)
	LR-6 (120-130)	LR-6 (210-220)
	LR-6 (130-140)	LR-6 (220-230)
	LR-6 (140-150)	LR-6 (230-240)
	LR-6 (150-160)	LR-6 (240-250)
	LR-6 (160-170)	LR-6 (250-260)
	LR-6 (170-180)	LR-7 (50-60)
	LR-6 (180-190)	LR-7 (60-70)
	LR-6 (190-200)	LR-7 (70-80)
	LR-6 (200-210)	LR-7 (90-100)
	LR-6 (210-220)	LR-7 (110-120)
	LR-6 (220-230)	LR-7 (130-140)
	LR-6 (230-240)	LR-7 (140-150)
	LR-6 (240-250)	LR-7 (150-160)
	LR-6 (250-260)	LR-7 (160-170)
	LR-7 (30-40)	LR-7 (170-180)
	LR-7 (40-50)	LR-7 (180-190)
	LR-7 (50-60)	LR-7 (200-210)
	LR-7 (60-70)	LR-8 (10-20)
	LR-7 (70-80)	LR-8 (20-30)
	LR-7 (80-90)	LR-8 (30-40)
	LR-7 (90-100)	LR-8 (40-50)
	LR-7 (100-110)	LR-8 (50-60)
	LR-7 (110-120)	LR-8 (60-70)
	LR-7 (130-140)	*LR-8 (70-80)*
	LR-7 (140-150)	LR-9 (0-10)
	LR-7 (150-160)	LR-9 (10-20)
	LR-7 (160-170)	LR-9 (20-30)
	LR-7 (170-180)	LR-9 (30-40)
	LR-7 (180-190)	LR-9 (40-50)
	LR-7 (190-200)	LR-9 (120-130)
	LR-7 (200-210)	LR-9 (130-140)

TABLE C-5
(Concluded)

Geochemical Classification (See Table 3.3-3, FEISS)	Evaluation Criteria	
	NNP[1]	ANP[2]:AGP[3]
Group 3 (Cont.)	LR-8 (10-20)	LR-10 (0-10)
	LR-8 (20-30)	LR-10 (10-20)
	LR-8 (30-40)	LR-10 (40-50)
	LR-8 (40-50)	LR-10 (60-70)
	LR-8 (50-60)	LR-10 (80-90)
	LR-8 (60-70)	LR-10 (90-100)
	LR-8 (70-80)	LR-11 (70-80)
	LR-8 (80-90)	LR-11 (80-90)
	LR-8 (90-100)	LR-11 (90-100)
	LR-9 (0-10)	LR-11 (100-110)
	LR-9 (10-20)	LR-11 (120-130)
	LR-9 (20-30)	LR-11 (130-140)
	LR-9 (30-40)	
	LR-9 (40-50)	
	LR-9 (50-60)	
	LR-9 (110-120)	
	LR-9 (120-130)	
	LR-9 (130-140)	
	LR-10 (0-10)	
	LR-10 (10-20)	
	LR-10 (40-50)	
	LR-10 (50-60)	
	LR-10 (60-70)	
	LR-10 (70-80)	
	LR-10 (80-90)	
	LR-10 (90-100)	
	LR-11 (0-10)	
	LR-11 (10-20)	
	LR-11 (60-70)	
	LR-11 (70-80)	
	LR-11 (80-90)	
	LR-11 (90-100)	
	LR-11 (100-110)	
	LR-11 (110-120)	
	LR-11 (120-130)	
	LR-11 (130-140)	
	LR-11 (140-150)	

Source: Revised from Golder 1993.

1 - Net neutralizing potential
2 - Acid neutralizing potential
3 - Acid generating potential



ECHO BAY LAMEFOOT PROJECT

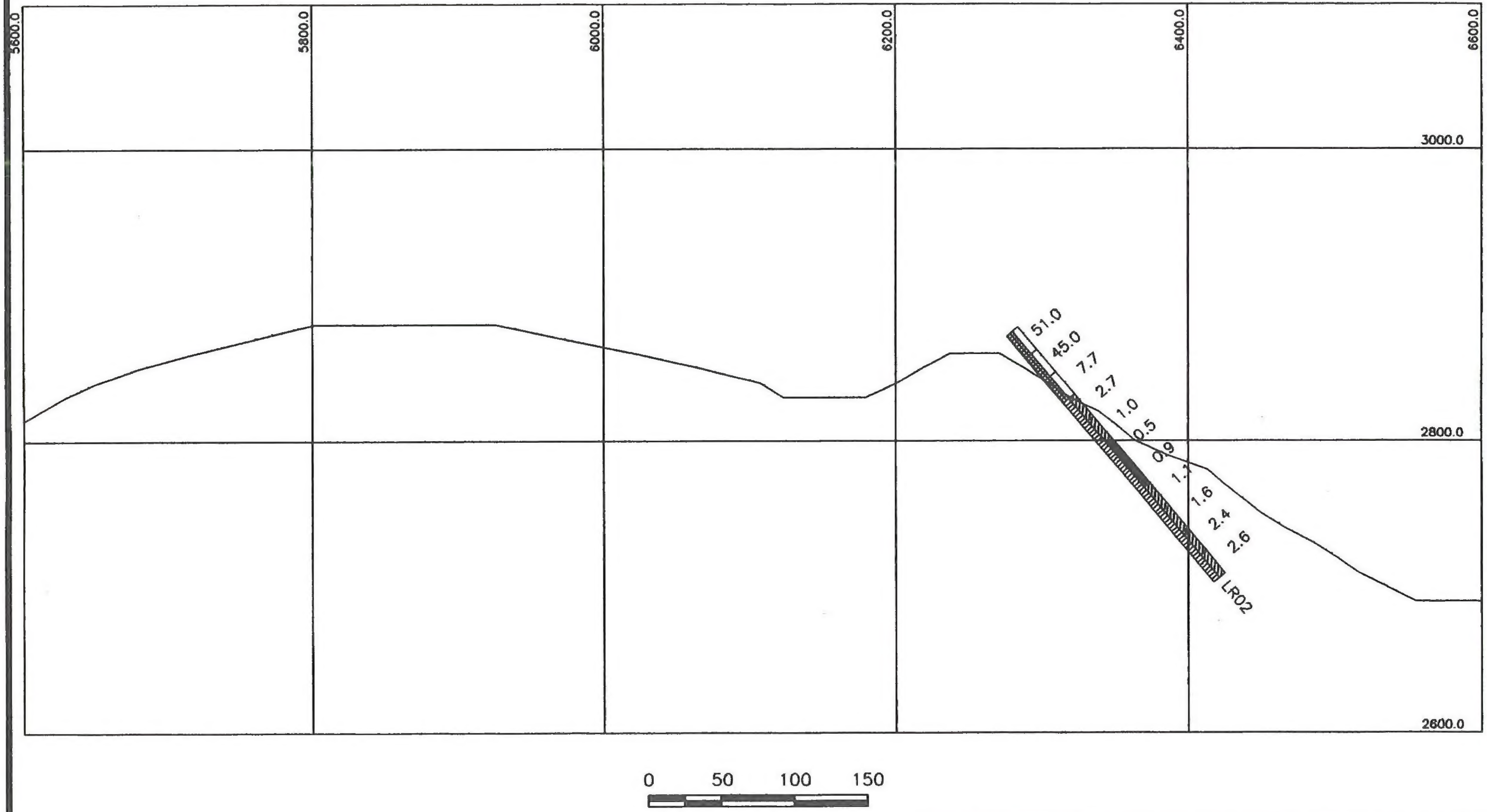
SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR-1 LOCATION AND ANP: AGP RATIO

DATE: JUNE 1994	SCALE:	FIG. NO. C-1

27300SEC



ECHO BAY LAMEFOOT PROJECT

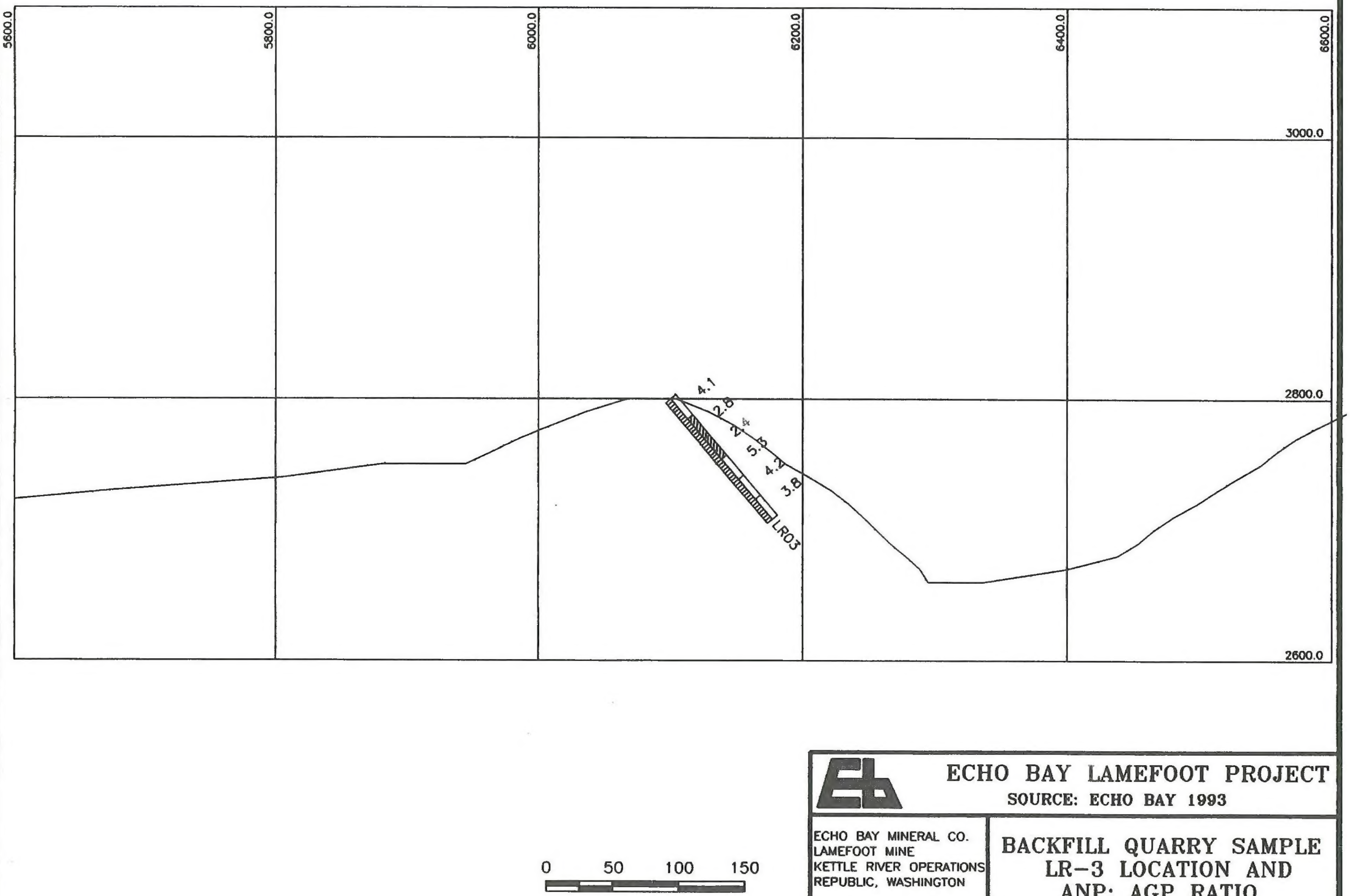
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR–2 LOCATION AND ANP: AGP RATIO

DATE: JUNE 1994 SCALE: FIG. NO. C-2

26700SEC



ECHO BAY LAMEFOOT PROJECT

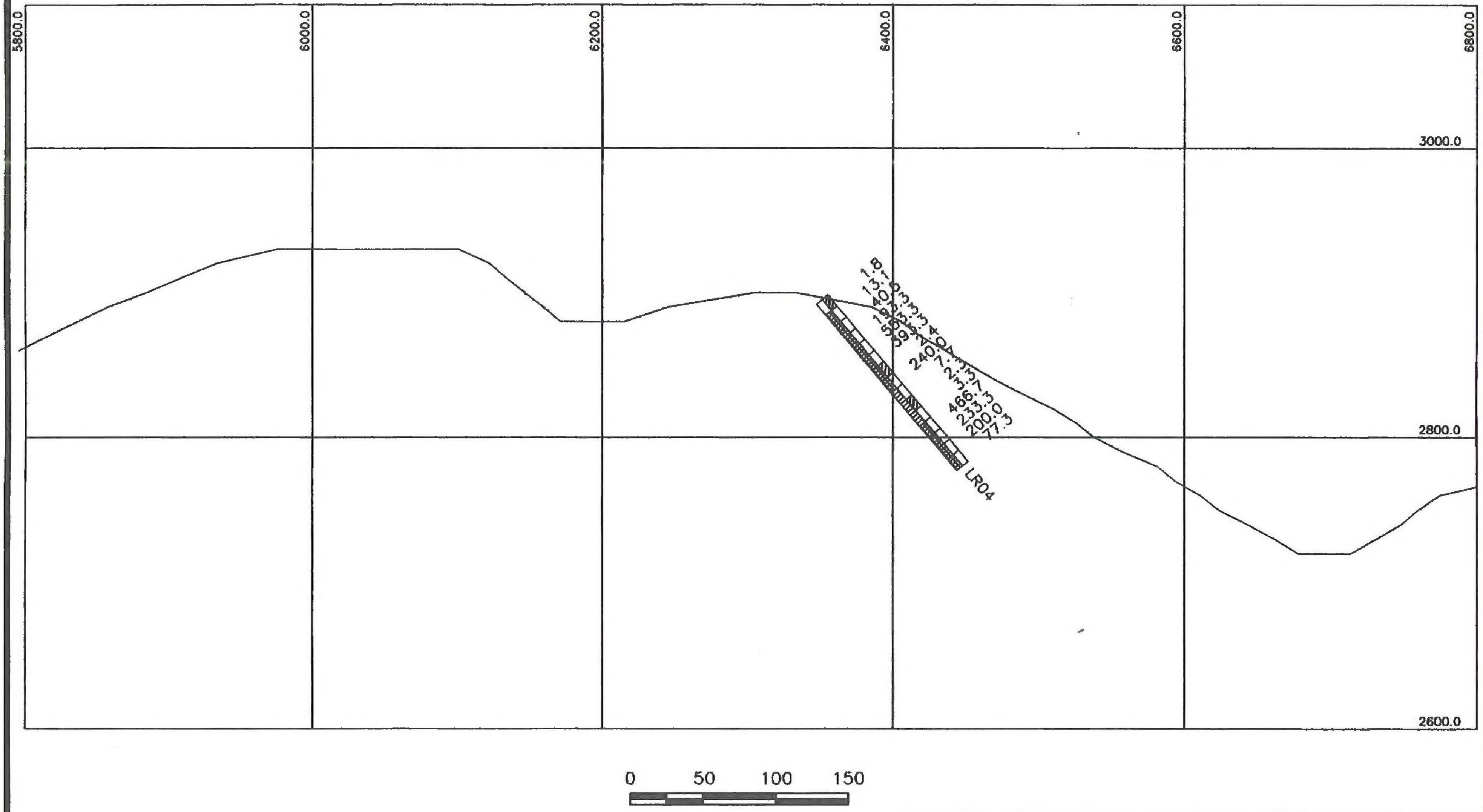
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR–3 LOCATION AND ANP: AGP RATIO

DATE: JUNE 1994	SCALE:	FIG. NO. C-3

26000SEC



ECHO BAY LAMEFOOT PROJECT

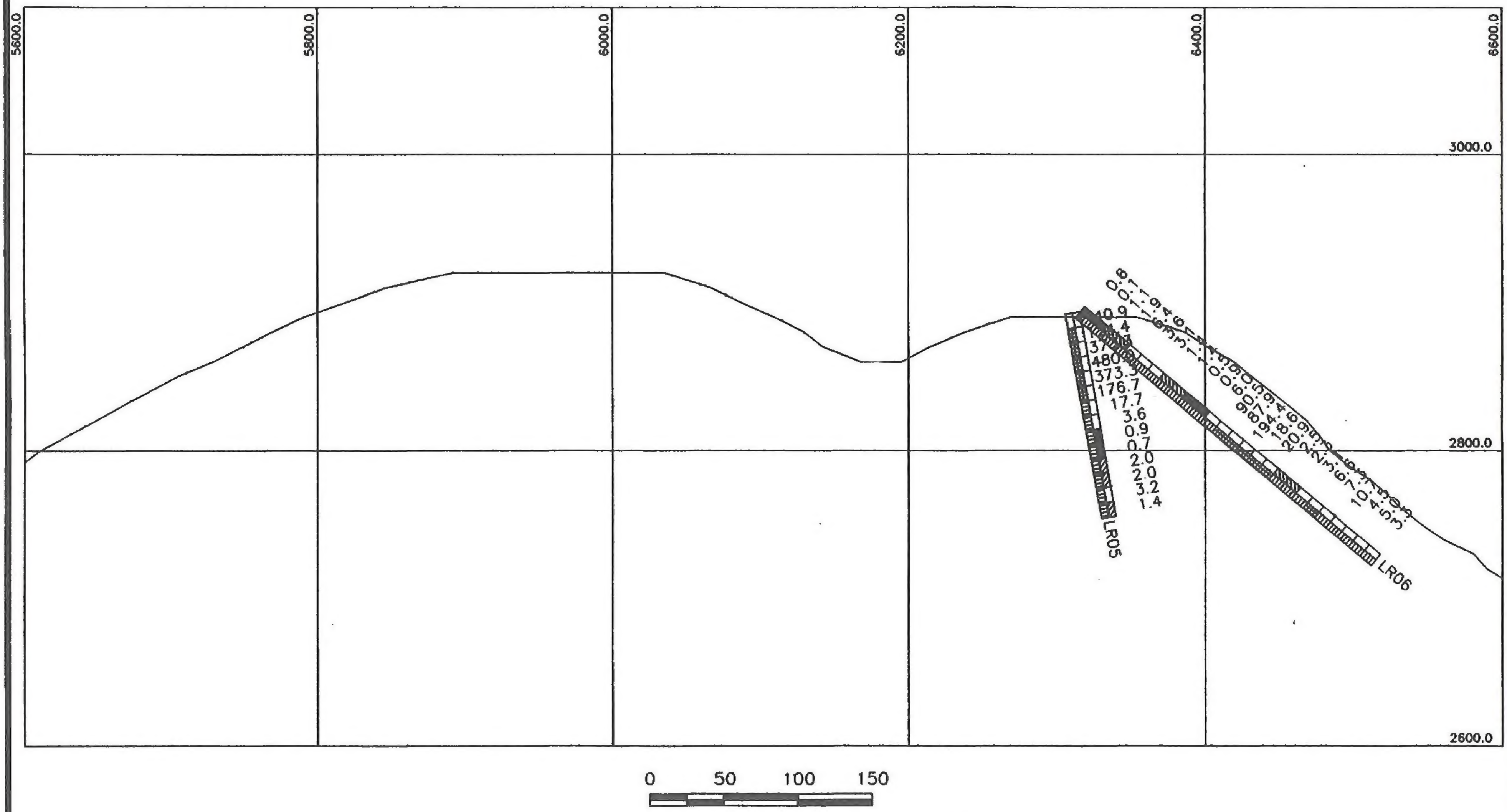
SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR-4 LOCATION AND ANP: AGP RATIO

DATE: JUNE 1994 | SCALE: | FIG. NO. C-4

27100SEC



ECHO BAY LAMEFOOT PROJECT

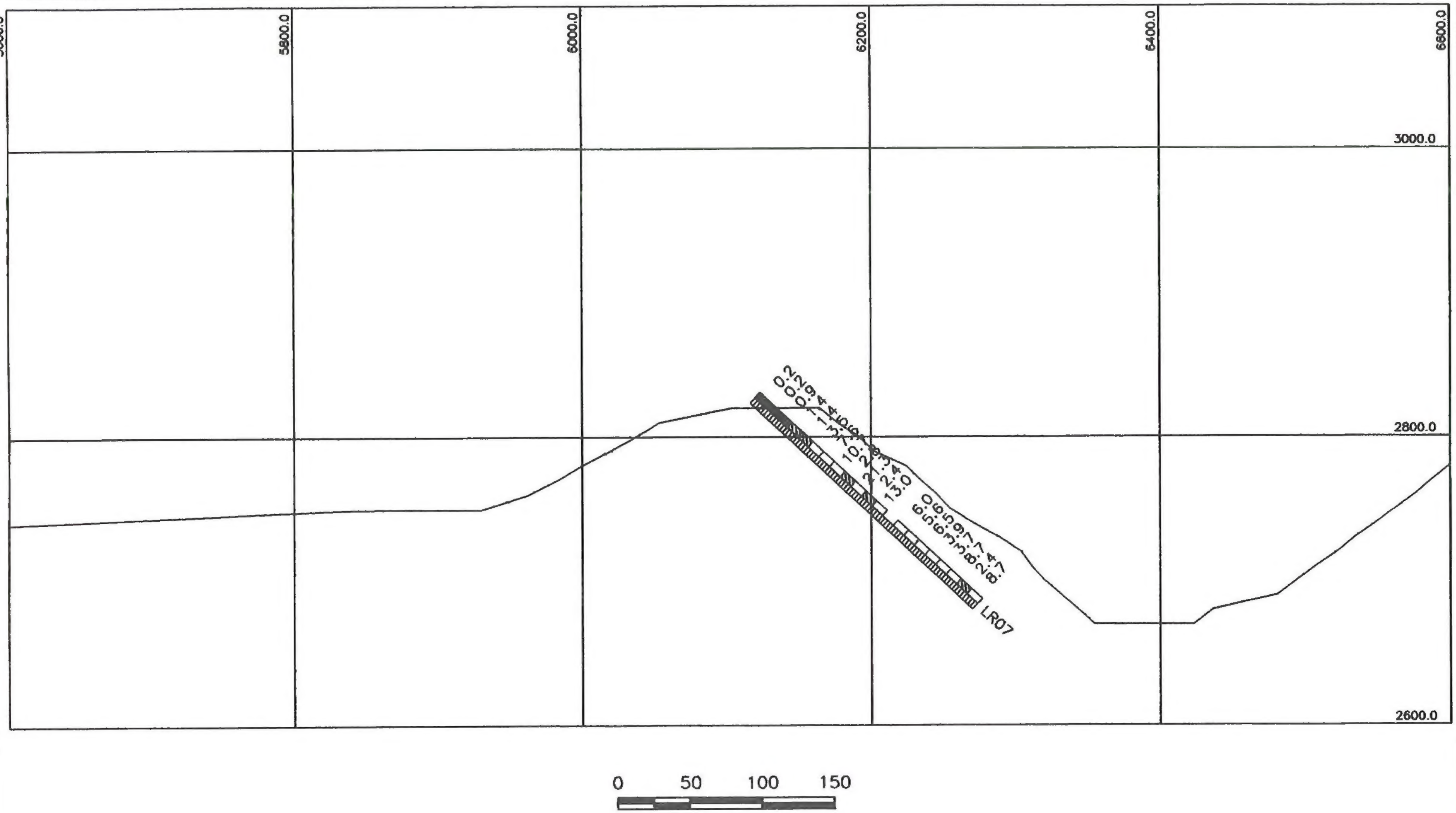
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR-5 & LR-6 LOCATIONS AND ANP: AGP RATIO

DATE: JUNE 1994 | SCALE: | FIG. NO. C-5

26900SEC



ECHO BAY LAMEFOOT PROJECT

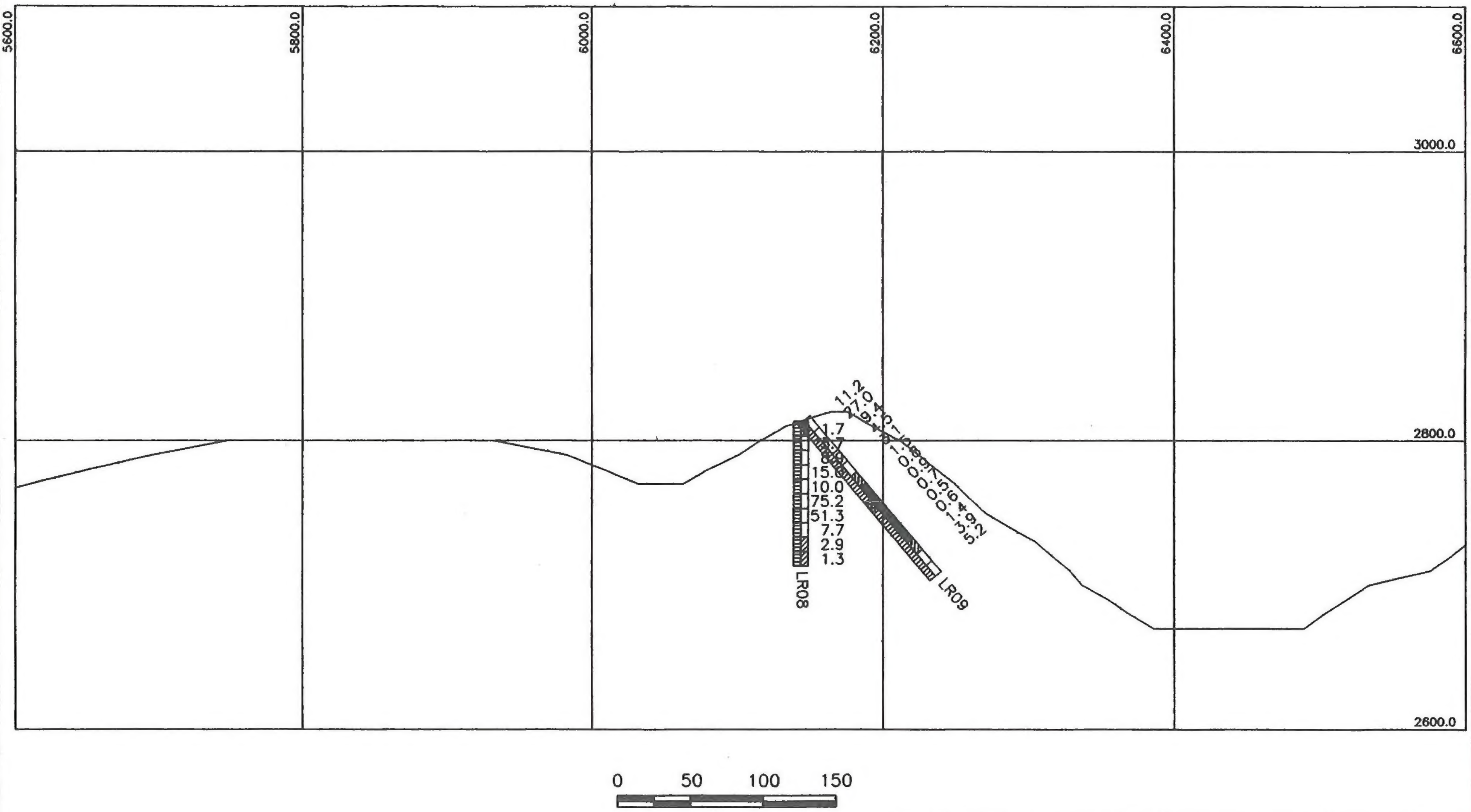
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR-7 LOCATION AND ANP: AGP RATIO

DATE: JUNE 1994
SCALE:
FIG. NO. C-6

26100SEC



ECHO BAY LAMEFOOT PROJECT

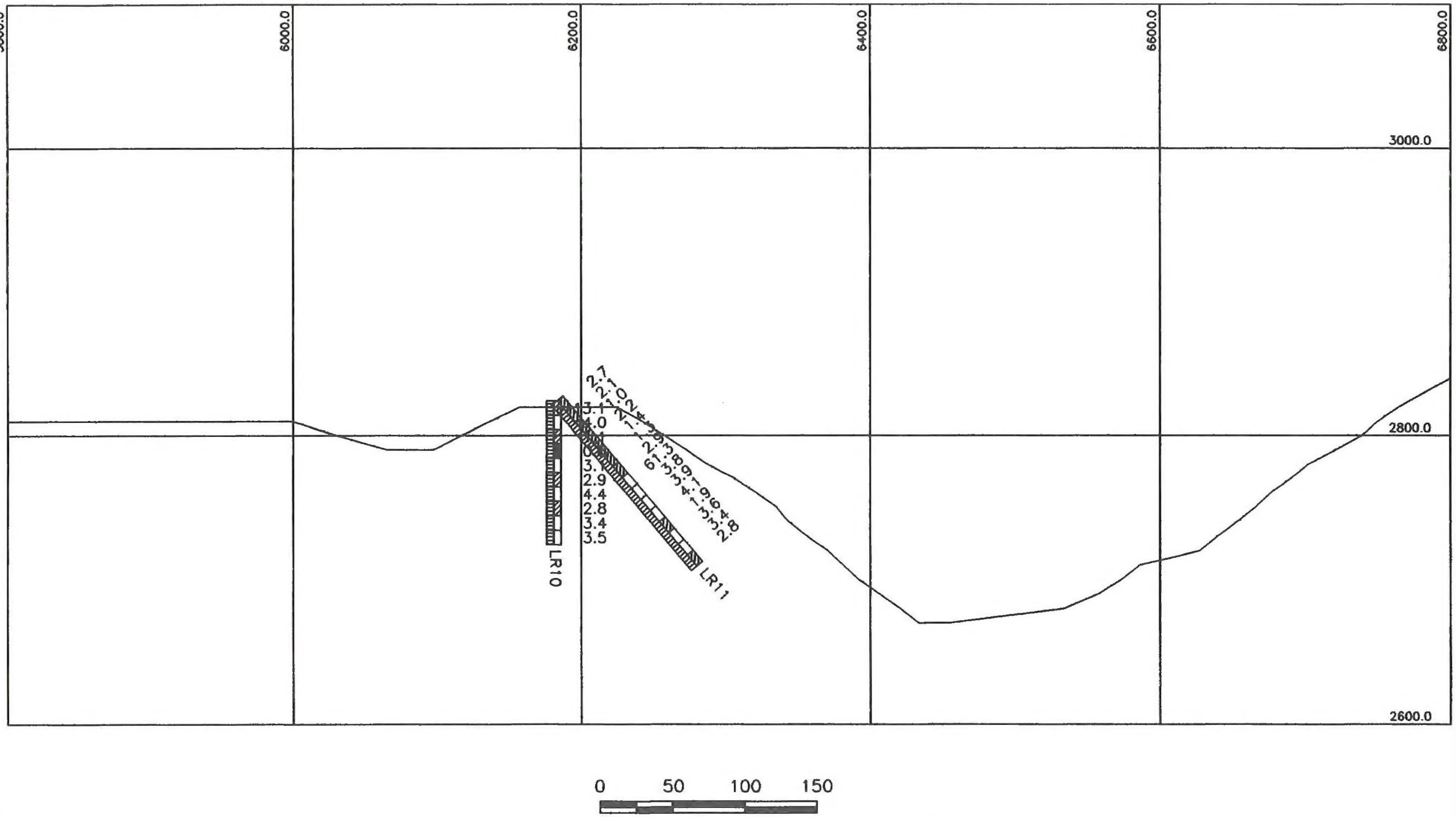
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR-8 & LR-9 LOCATIONS ANP: AGP RATIO

DATE: JUNE 1994
SCALE:
FIG. NO. C-7

26400SEC



ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

BACKFILL QUARRY SAMPLE LR–10 & LR–11 LOCATIONS AND ANP: AGP RATIO

DATE: JUNE 1994 | SCALE: | FIG. NO. C-8

26500SEC

TABLE C-6

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
April 30, 1994

CLIENT SAMPLE I.D...: LF KIN 1
LAB SAMPLE I.D......: 940148-1

PARAMETER	UNITS	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Leachate Quantity	mls	146	143	145	139	143	138	138	136	140	136
pH	pH Units	7.58	7.47	6.43	7.45	8.03	8.00	7.96	7.88	7.63	7.80
Conductivity	umohs/cm	102	336	328	221	181	149	114	99	97	89
Sulfate	mg/L	28	129	121	69	59	46	<10	33	23	16
Cumulative Sulfate	Total mg	4	23	40	50	58	64	64	69	72	74
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	0	0	0	0	0	0	0	0	0	0
Alkalinity	mg/L CaCO3	21	16	18	20	19	21	24	26	23	29
Cumulative Alkalinity	Tot. mg CaCO3	3	5	8	11	13	16	20	23	26	30
pH of DI H2O	pH Units	5.38	6.08	5.74	5.64	5.54	5.64	5.71	5.67	5.79	5.58

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core
[redacted] [redacted] atories [redacted] ssumes [redacted] ibility a[redacted] o warra[redacted] [illegible] [redacted] [illegible] [redacted] [illegible] [redacted] [illegible] [redacted] [illegible] [redacted] [illegible] [redacted] well u[redacted] nnectio[redacted] h such r[redacted] d or reli[redacted] any rea[redacted] [redacted]

TABLE C-6

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
April 30, 1994

CLIENT SAMPLE I.D...: LF KIN 2
LAB SAMPLE I.D......: 940148-2

PARAMETER	UNITS	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Leachate Quantity	mls	147	142	146	140	140	138	121	140	135	136
pH	pH Units	7.69	7.58	6.73	7.64	8.07	8.32	7.88	8.45	7.76	7.87
Conductivity	umohs/cm	119	338	294	222	160	149	93	95	86	77
Sulfate	mg/L	34	127	103	90	44	38	25	25	16	12
Cumulative Sulfate	Total mg	5	23	38	51	57	62	65	69	71	72
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	0	0	0	0	0	0	0	0	0	0
Alkalinity	mg/L CaCO3	23	18	22	23	22	22	25	26	27	28
Cumulative Alkalinity	Tot. mg CaCO3	3	6	9	12	15	18	22	25	29	33
pH of DI H2O	pH Units	5.38	6.08	5.74	5.64	5.54	5.64	5.71	5.67	5.79	5.58

The analyses, opinions or interpretations contained in this report are based upon [illegible] for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories, however, assumes no responsibility and [illegible] properly, well or sand in connection with which such report is used or relied upon for any reason

TABLE C-6

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
April 30, 1994

CLIENT SAMPLE I.D...: LF KIN 3
LAB SAMPLE I.D......: 940148-3

PARAMETER	UNITS	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Leachate Quantity	mls	148	142	141	135	140	141	138	135	132	137
pH	pH Units	8.62	8.93	7.79	8.04	9.13	9.18	8.75	9.20	8.00	8.08
Conductivity	umohs/cm	81	108	126	113	106	134	83	82	82	72
Sulfate	mg/L	11	17	19	19	<10	<10	11	<10	<10	<10
Cumulative Sulfate	Total mg	2	4	7	9	9	9	11	11	11	11
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	<0.03	<0.03	0.04	0.03	<0.03	<0.03	0.05	0.05	0.07	0.05
Cumulative Iron	Total ug	0	0	6	10	10	10	17	23	33	39
Alkalinity	mg/L CaCO3	34	34	40	39	42	39	38	37	41	36
Cumulative Alkalinity	Tot. mg CaCO3	5	10	16	21	27	32	37	42	48	53
pH of DI H2O	pH Units	5.38	6.08	5.74	5.64	5.54	5.64	5.71	5.67	5.79	5.58

[illegible] analyses [illegible] interp[illegible] contained [illegible] are [illegible] observ[illegible] the cl[illegible] ose excl[illegible] confiden[illegible] report [illegible] lations [illegible] expressed [illegible] the b[illegible] of Core Laboratories [illegible]
Laboratories however assumes no responsib[illegible] well [illegible] connection [illegible] such re[illegible] or reli[illegible] any reason

TABLE C-6

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
April 30, 1994

CLIENT SAMPLE I.D...: LF KIN 4
LAB SAMPLE I.D......: 940148-4

PARAMETER	UNITS	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Leachate Quantity	mls	142	149	147	136	131	134	134	124	125	120
pH	pH Units	7.34	7.60	6.66	7.22	7.71	7.61	7.73	7.74	7.52	7.75
Conductivity	umohs/cm	86	90	109	126	126	92	82	83	85	76
Sulfate	mg/L	21	24	27	48	28	32	<10	14	13	12
Cumulative Sulfate	Total mg	3	7	11	17	21	25	25	27	28	30
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	0	0	0	0	0	4	4	4	4	4
Alkalinity	mg/L CaCO3	20	17	19	17	19	19	22	21	27	25
Cumulative Alkalinity	Tot. mg CaCO3	3	5	8	10	13	16	18	21	24	27
pH of DI H2O	pH Units	5.38	6.08	5.74	5.64	5.54	5.64	5.71	5.67	5.79	5.58

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories, however, assumes no responsibility and makes no warranty or [illegible] profitableness of any [illegible] property, well or sand in connection with which such report is used or relied upon for any reason.

Western Atlas International

TABLE C-6

CORE LABORATORIES

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
April 30, 1994

CLIENT SAMPLE I.D...: LF KIN 5
LAB SAMPLE I.D......: 940148-5

PARAMETER	UNITS	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Leachate Quantity	mls	134	138	140	140	137	138	134	136	129	130
pH	pH Units	7.63	7.72	6.65	7.48	7.82	7.70	7.85	7.61	7.61	7.60
Conductivity	umohs/cm	67	75	70	76	72	111	66	48	55	50
Sulfate	mg/L	10	<10	<10	22	<10	10	29	<10	<10	<10
Cumulative Sulfate	Total mg	1	1	1	4	4	6	10	10	10	10
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	0	0	0	0	0	0	0	0	0	0
Alkalinity	mg/L CaCO3	24	25	20	18	21	20	23	20	20	21
Cumulative Alkalinity	Tot. mg CaCO3	3	7	9	12	15	18	21	23	26	29
pH of DI H2O	pH Units	5.38	6.08	5.74	5.64	5.54	5.64	5.71	5.67	5.79	5.58

TABLE C-6

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
April 30, 1994

CLIENT SAMPLE I.D...: LF KIN 6
LAB SAMPLE I.D......: 940148-6

PARAMETER	UNITS	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Leachate Quantity	mls	146	142	127	129	137	135	127	130	126	127
pH	pH Units	7.68	7.70	6.88	7.52	7.80	7.88	7.95	7.64	7.76	7.59
Conductivity	umohs/cm	56	70	90	79	63	64	65	53	74	54
Sulfate	mg/L	<10	<10	<10	16	<10	<10	<10	<10	<10	<10
Cumulative Sulfate	Total mg	0	0	0	2	2	2	2	2	2	2
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	0	0	0	0	0	0	0	0	0	0
Alkalinity	mg/L CaCO3	26	25	40	27	23	26	30	24	38	25
Cumulative Alkalinity	Tot. mg CaCO3	4	7	12	16	19	23	26	30	34	37
pH of DI H2O	pH Units	5.38	6.08	5.74	5.64	5.54	5.64	5.71	5.67	5.79	5.58

The analyses, opinions or interpretations contained in this report are based upon [illegible] whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core [illegible] in connection with which such report is used or relied upon for any reason

FIGURE C-9

HUMIDITY CELL TESTS

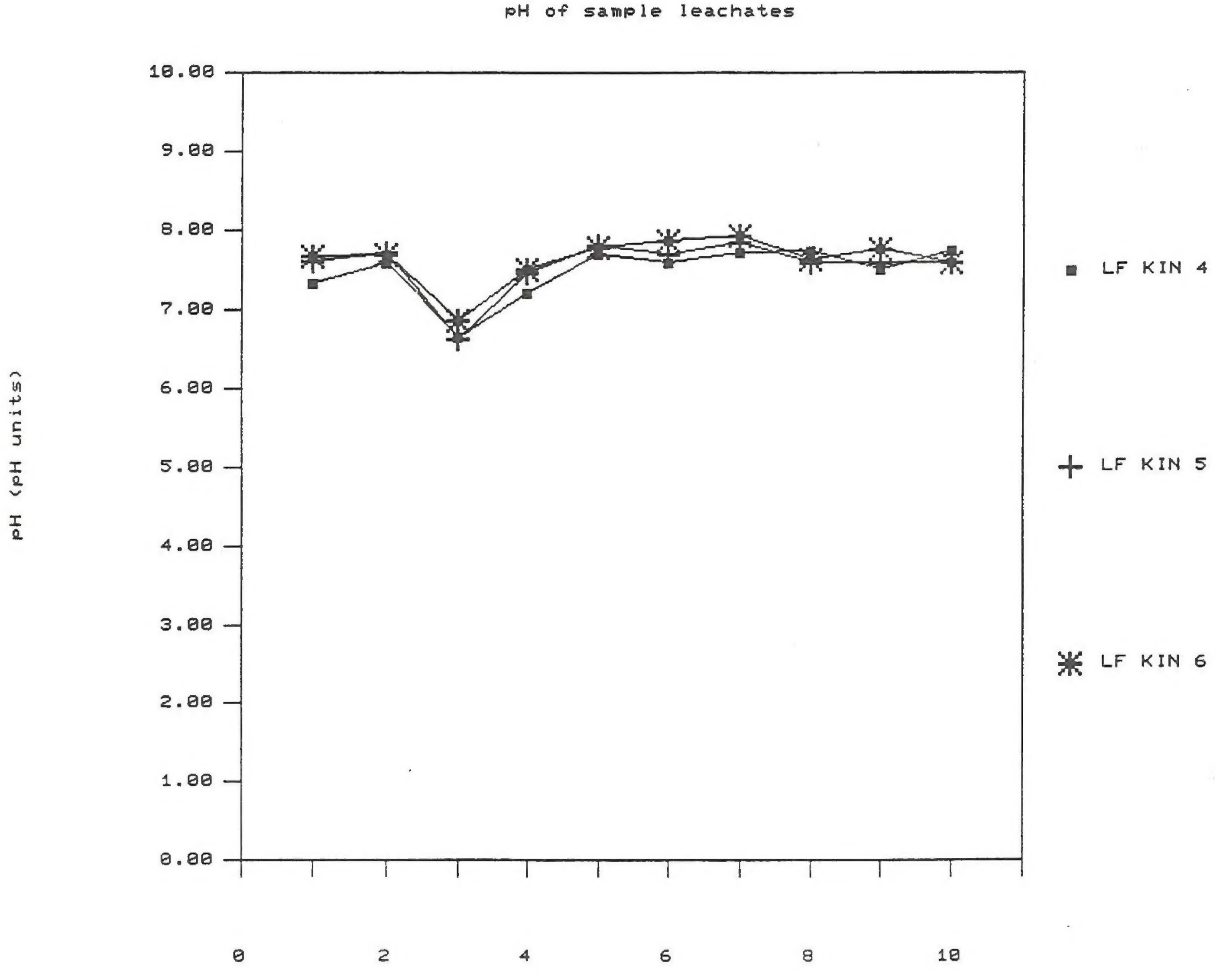


FIGURE C-10

HUMIDITY CELL TESTS

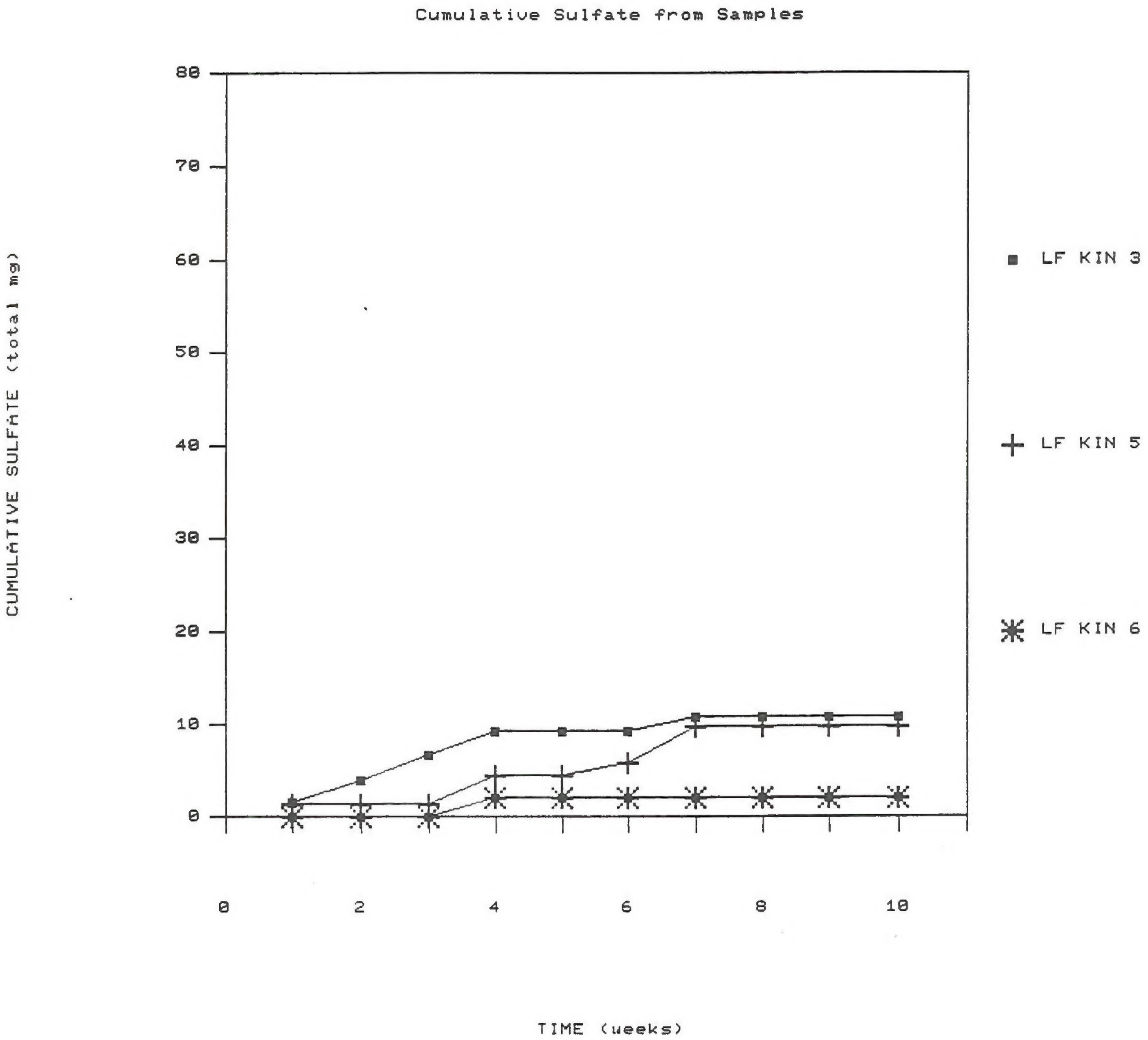


FIGURE C-11

HUMIDITY CELL TESTS

Cumulative Iron from Samples

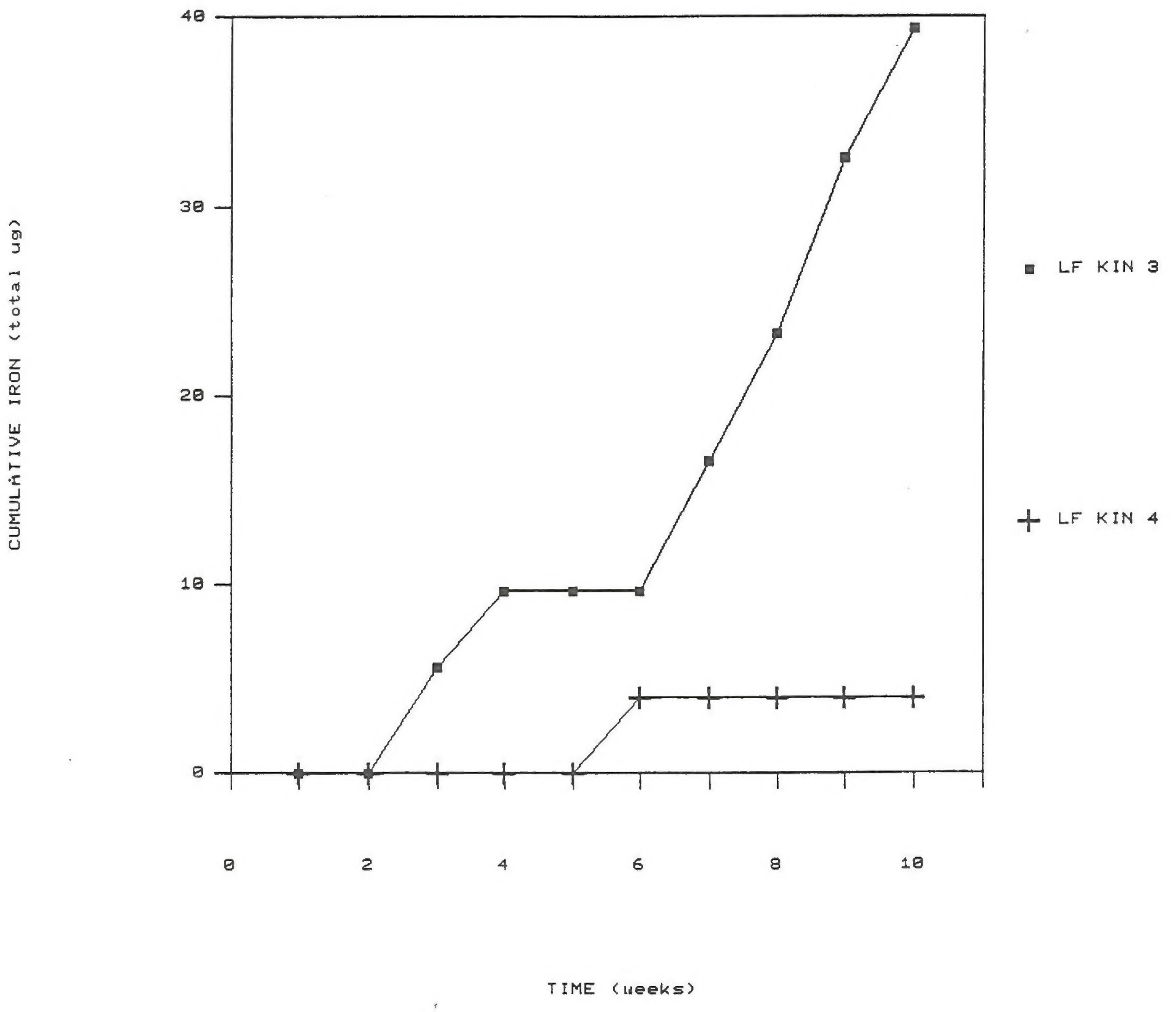


FIGURE C-12

HUMIDITY CELL TESTS

Cumulative Alkalinity from Samples

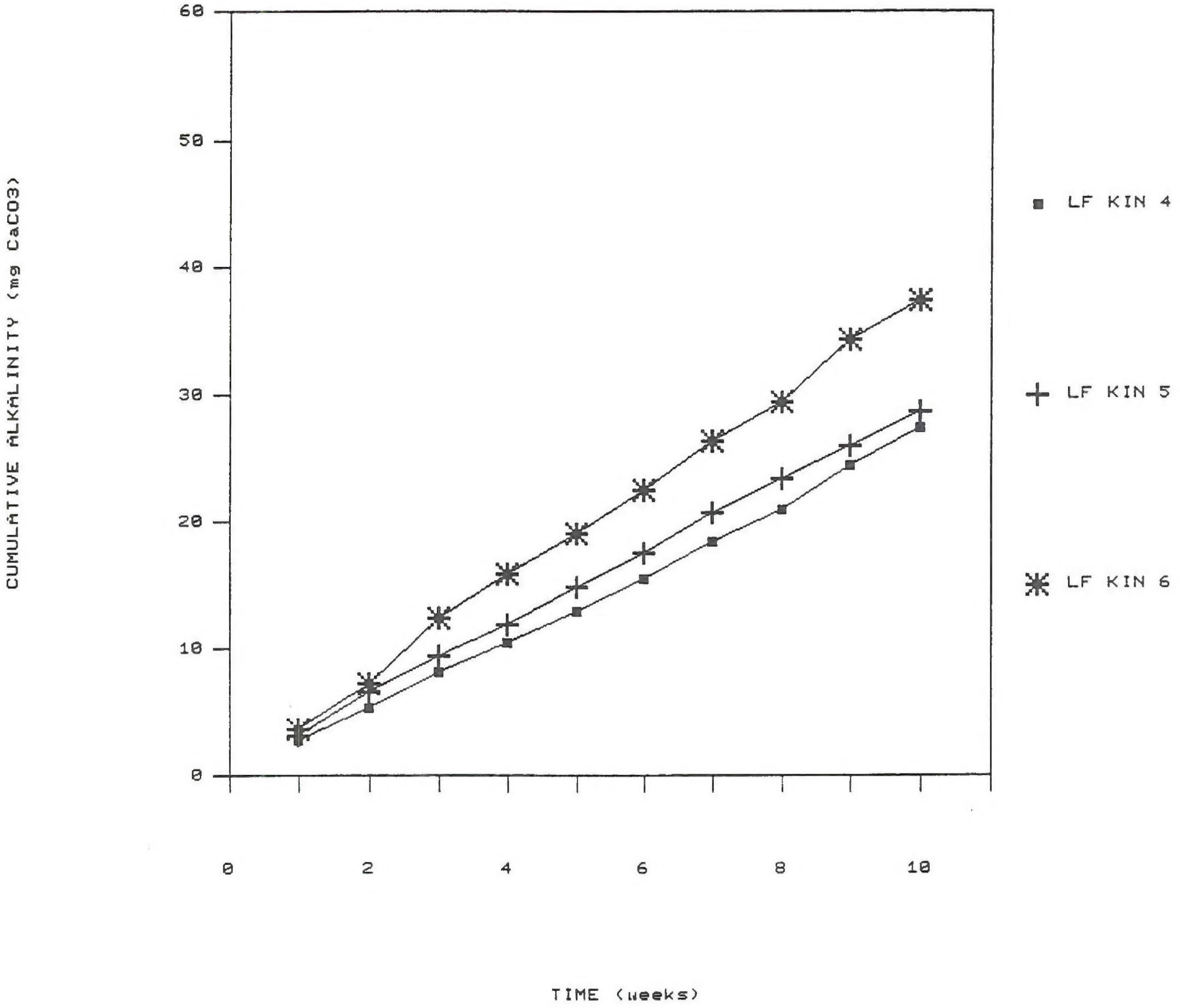
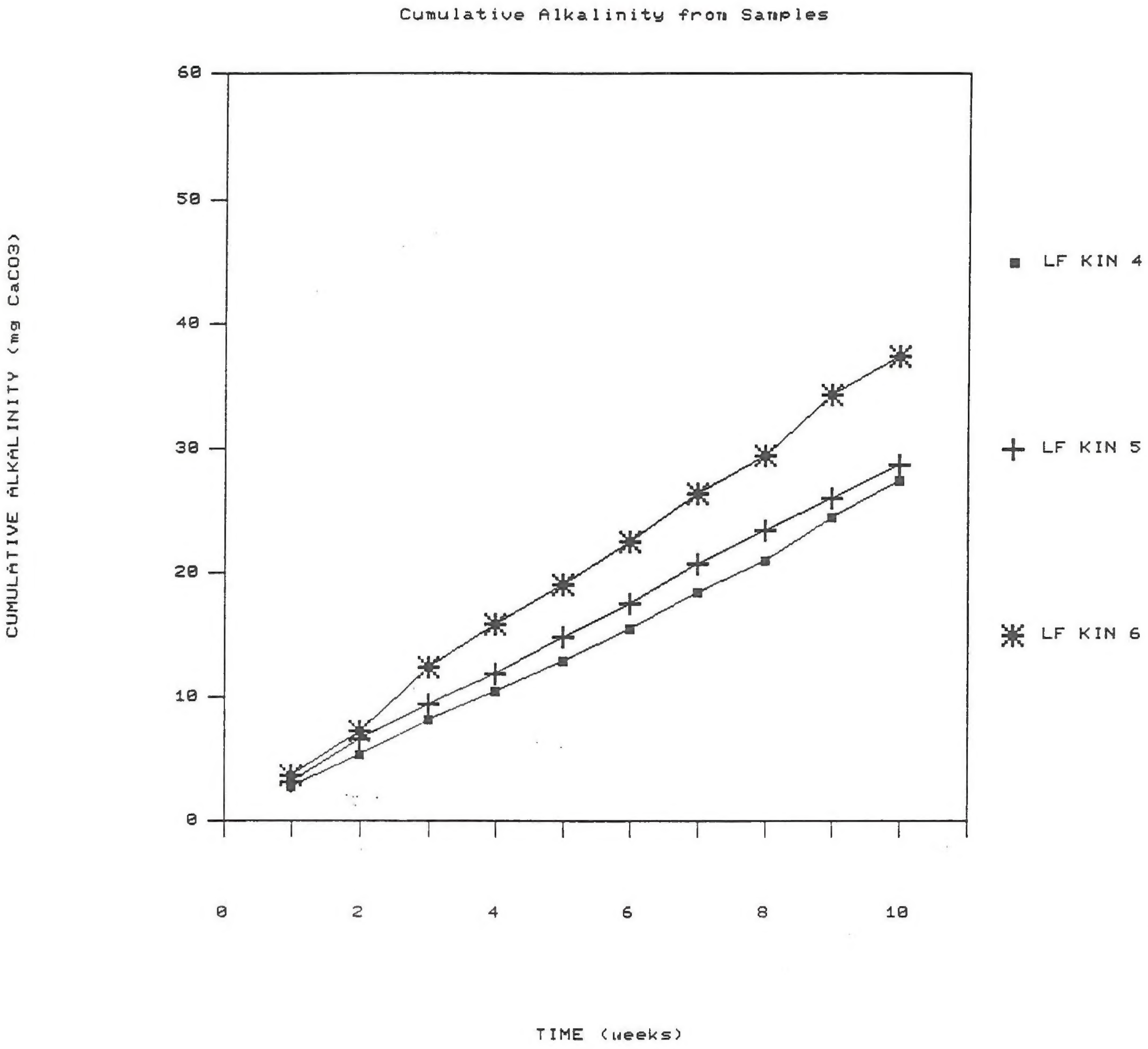


FIGURE C-13



HUMIDITY CELL TESTS
Cumulative Alkalinity from Samples
CUMULATIVE ALKALINITY (mg CaCO3)
60
50
40
30
20
10
0
0
2
4
6
8
10
TIME (weeks)
■ LF KIN 4
+ LF KIN 5
✳ LF KIN 6

FIGURE C-14

HUMIDITY CELL TESTS

Cumulative Sulfate from Samples

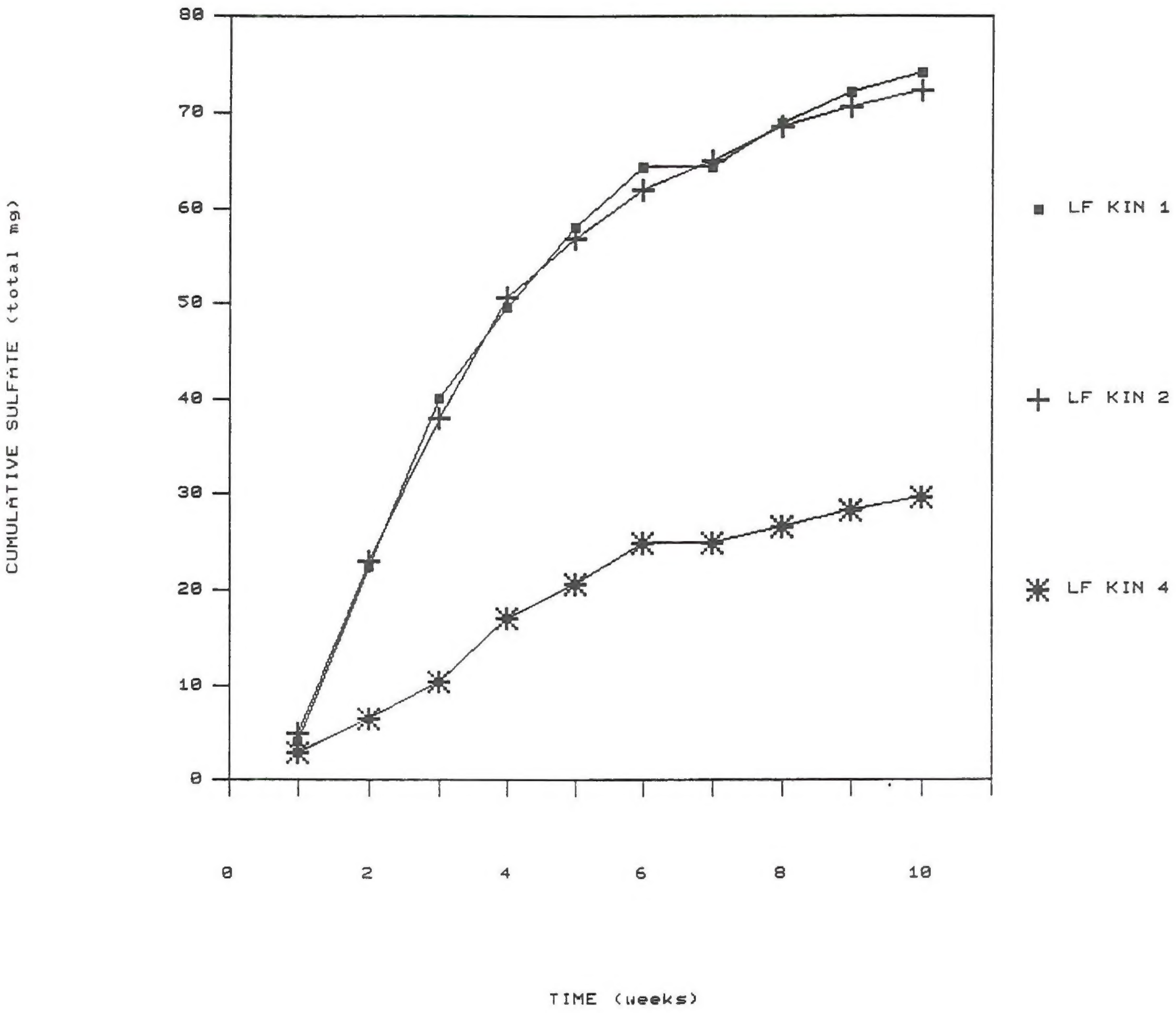


FIGURE C-15

HUMIDITY CELL TESTS

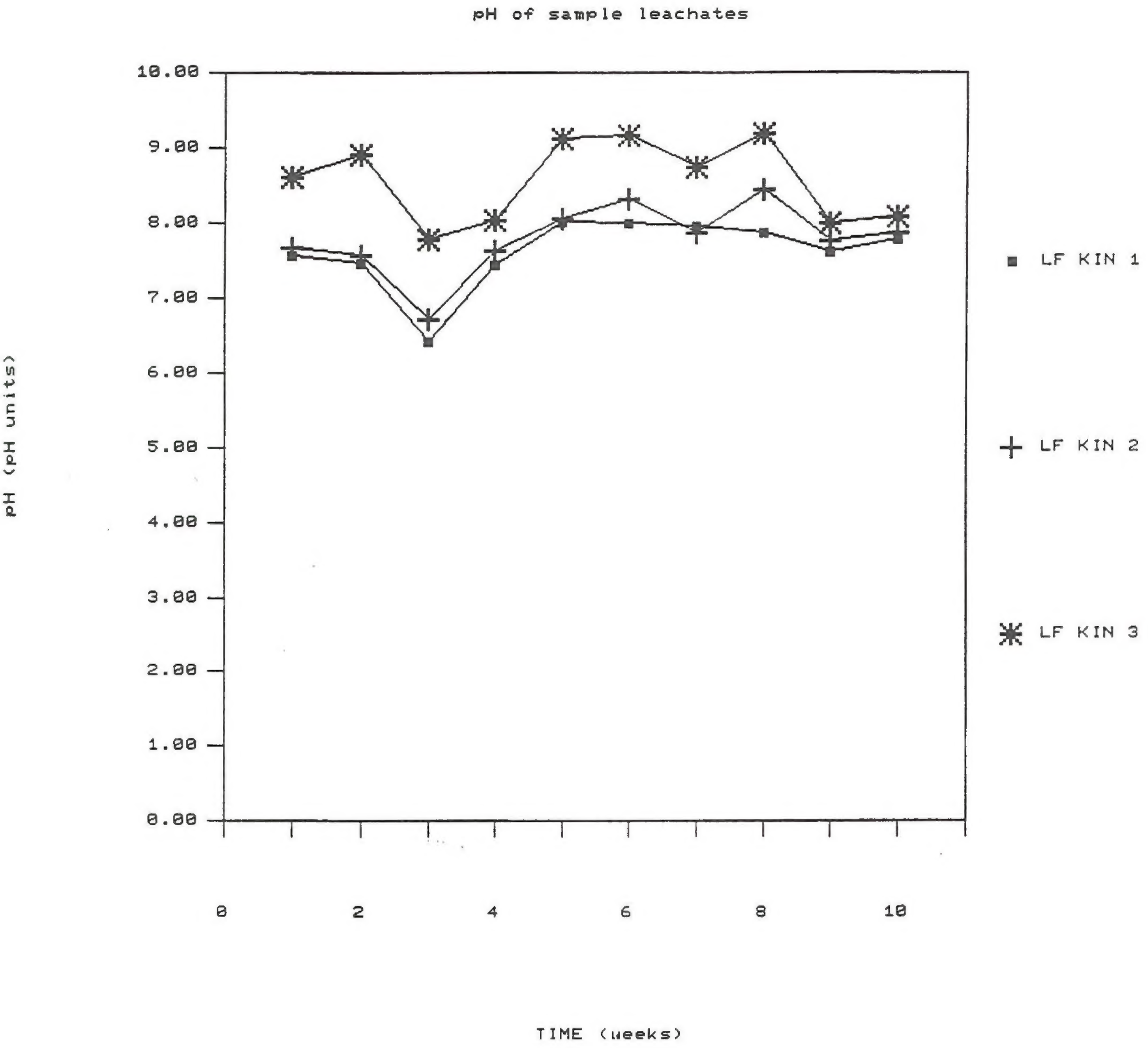


TABLE C-7

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
July 22, 1994

CLIENT SAMPLE I.D...: LF KIN 1
LAB SAMPLE I.D......: 940148-1

PARAMETER	UNITS	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20
Leachate Quantity	mls	142	137	145	138	145	142	140	135	144	187
pH	pH Units	7.68	7.64	7.81	7.63	7.25	7.23	7.48	7.47	7.48	8.06
Conductivity	umohs/cm	84	111	106	176	121	90	105	83	72	65
Sulfate	mg/L	14	14	<10	16	17	19	20	13	14	<10
Cumulative Sulfate	Total mg	2	4	4	6	9	11	14	16	18	18
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	0.07	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	10	10	10	10	10	10	10	10	10	10
Alkalinity	mg/L CaCO3	29	30	38	51	33	25	27	24	22	23
Cumulative Alkalinity	Tot. mg CaCO3	4	8	14	21	26	29	33	36	39	44
pH of DI H2O	pH Units	5.54	5.44	5.60	5.69	5.54	5.31	5.70	5.80	5.89	5.80

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories, however, assumes no responsibility and makes no warranty or representations, express or implied, as to the productivity, proper operations, or profitableness of any oil, gas, coal or other mineral, property, well or sand in connection with which such report is used or relied upon for any reason whatsoever. This report shall not be reproduced except in its entirety, with [illegible]

TABLE C-7

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
July 22, 1994

CLIENT SAMPLE I.D...: LF KIN 2
LAB SAMPLE I.D......: 940148-2

PARAMETER	UNITS	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20
Leachate Quantity	mls	140	141	138	138	138	138	135	131	166	181
pH	pH Units	7.60	7.74	7.83	7.87	7.36	7.46	7.57	7.54	7.70	8.39
Conductivity	umohs/cm	81	86	102	96	83	82	94	68	73	85
Sulfate	mg/L	12	10	10	12	11	11	13	11	13	17
Cumulative Sulfate	Total mg	2	3	4	6	8	9	11	12	15	18
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	0.06	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	8	8	8	8	8	8	8	8	8	8
Alkalinity	mg/L CaCO3	29	33	38	32	30	32	33	27	26	26
Cumulative Alkalinity	Tot. mg CaCO3	4	9	14	18	23	27	31	35	39	44
pH of DI H2O	pH Units	5.54	5.44	5.60	5.69	5.54	5.31	5.70	5.80	5.89	5.80

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core
[redacted] [redacted]ories, ho[redacted]umes n[redacted]ility and [redacted] warranty[redacted]ntations [redacted] implied[redacted] productiv[redacted] operatio[redacted]tablenes[redacted] gas, c[redacted] mineral[redacted] well or s[redacted]nection w[redacted]uch rep[redacted]r relied [redacted]y reaso[redacted] [redacted]

TABLE C-7

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
July 22, 1994

CLIENT SAMPLE I.D...: LF KIN 3
LAB SAMPLE I.D......: 940148-3

PARAMETER	UNITS	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20
Leachate Quantity	mls	136	141	136	132	141	134	139	143	141	181
pH	pH Units	7.86	7.82	7.95	7.76	7.29	7.46	7.55	7.64	7.62	8.24
Conductivity	umohs/cm	71	72	90	83	69	64	62	60	54	58
Sulfate	mg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Sulfate	Total mg	0	0	0	0	0	0	0	0	0	0
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	0.10	<0.03	0.03	0.03	<0.03	<0.03	<0.03	0.03	0.04	<0.03
Cumulative Iron	Total ug	14	14	18	22	22	22	22	26	32	32
Alkalinity	mg/L CaCO3	41	38	42	32	34	32	28	33	27	30
Cumulative Alkalinity	Tot. mg CaCO3	6	11	17	21	26	30	34	39	42	48
pH of DI H2O	pH Units	5.54	5.44	5.60	5.69	5.54	5.31	5.70	5.80	5.89	5.80

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories, however, assumes no responsibility and makes no warranty or representations, express or implied, as to the productivity, proper operations, or profitableness of any oil, gas, coal or other mineral, property, well or sand in connection with which such report is used or relied upon for any reason whatsoever. This report [illegible]

TABLE C-7

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
July 22, 1994

CLIENT SAMPLE I.D...: LF KIN 4
LAB SAMPLE I.D......: 940148-4

PARAMETER	UNITS	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20
Leachate Quantity	mls	124	125	121	119	118	126	124	124	115	165
pH	pH Units	7.80	7.74	7.73	7.18	7.26	7.35	7.45	7.01	7.22	7.40
Conductivity	umohs/cm	80	93	148	125	92	87	69	63	52	62
Sulfate	mg/L	11	<10	<10	10	10	<10	10	<10	<10	<10
Cumulative Sulfate	Total mg	1	1	1	3	4	4	5	5	5	5
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	4	4	4	4	4	4	4	4	4	4
Alkalinity	mg/L CaCO3	28	37	56	43	33	33	32	22	21	25
Cumulative Alkalinity	Tot. mg CaCO3	3	8	15	20	24	28	32	35	37	41
pH of DI H2O	pH Units	5.54	5.44	5.60	5.69	5.54	5.31	5.70	5.80	5.89	5.80

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core [illegible]ories, ho[illegible]umes n[illegible]ility and [illegible] warranty [illegible]ntations [illegible] productiv[illegible] operatio[illegible]tablenes[illegible] gas, c[illegible] minera[illegible] well or s[illegible]nection w[illegible]such rep[illegible]or relied [illegible]ny reaso[illegible] [illegible] This report shall not [illegible]

TABLE C-7

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
July 22, 1994

CLIENT SAMPLE I.D...: LF KIN 5
LAB SAMPLE I.D......: 940148-5

PARAMETER	UNITS	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20
Leachate Quantity	mls	131	133	126	133	130	125	132	123	132	176
pH	pH Units	7.65	7.78	7.78	7.08	7.04	7.12	7.31	7.36	7.31	7.51
Conductivity	umohs/cm	54	70	126	82	58	56	63	47	39	48
Sulfate	mg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Sulfate	Total mg	0	0	0	0	0	0	0	0	0	0
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	0.04	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cumulative Iron	Total ug	5	5	5	5	5	5	5	5	5	5
Alkalinity	mg/L CaCO3	24	31	50	30	25	24	24	24	18	21
Cumulative Alkalinity	Tot. mg CaCO3	3	7	14	18	21	24	27	30	32	36
pH of DI H2O	pH Units	5.54	5.44	5.60	5.69	5.54	5.31	5.70	5.80	5.89	5.80

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories, however, assumes no responsibility and makes no warranty or representations, express or implied, as to the productivity, proper operations, or profitableness of any oil, gas, coal or other mineral, property, well or sand in connection with which such report is used or relied upon for any reason whatsoever. This report shall not be reproduced except in [illegible]

TABLE C-7

SUMMARY OF DATA GENERATED FROM HUMIDITY CELL TESTING
ECHO BAY MINERALS
July 22, 1994

CLIENT SAMPLE I.D...: LF KIN 6
LAB SAMPLE I.D......: 940148-6

PARAMETER	UNITS	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20
Leachate Quantity	mls	131	134	131	130	131	135	131	129	134	172
pH	pH Units	7.73	7.92	7.84	7.05	7.08	7.20	7.45	7.24	7.38	7.59
Conductivity	umohs/cm	60	69	139	85	65	62	59	53	40	69
Sulfate	mg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Sulfate	Total mg	0	0	0	0	0	0	0	0	0	0
Acidity	mg/L CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cumulative Acidity	Tot. mg CaCO3	0	0	0	0	0	0	0	0	0	0
Iron (Diss.)	mg/L	0.04	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03
Cumulative Iron	Total ug	5	5	5	5	5	5	5	5	9	9
Alkalinity	mg/L CaCO3	29	35	49	28	30	26	28	22	19	32
Cumulative Alkalinity	Tot. mg CaCO3	4	8	15	19	22	26	30	32	35	41
pH of DI H2O	pH Units	5.54	5.44	5.60	5.69	5.54	5.31	5.70	5.80	5.89	5.80

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories, however, assumes no responsibility and makes no warranty or representations, express or implied, as to the productivity, proper operations, or profitableness of any oil, gas, coal or other mineral, property, well or sand in connection with which such report is used or relied upon for any reason [illegible]

FIGURE C-16

HUMIDITY CELL TESTS

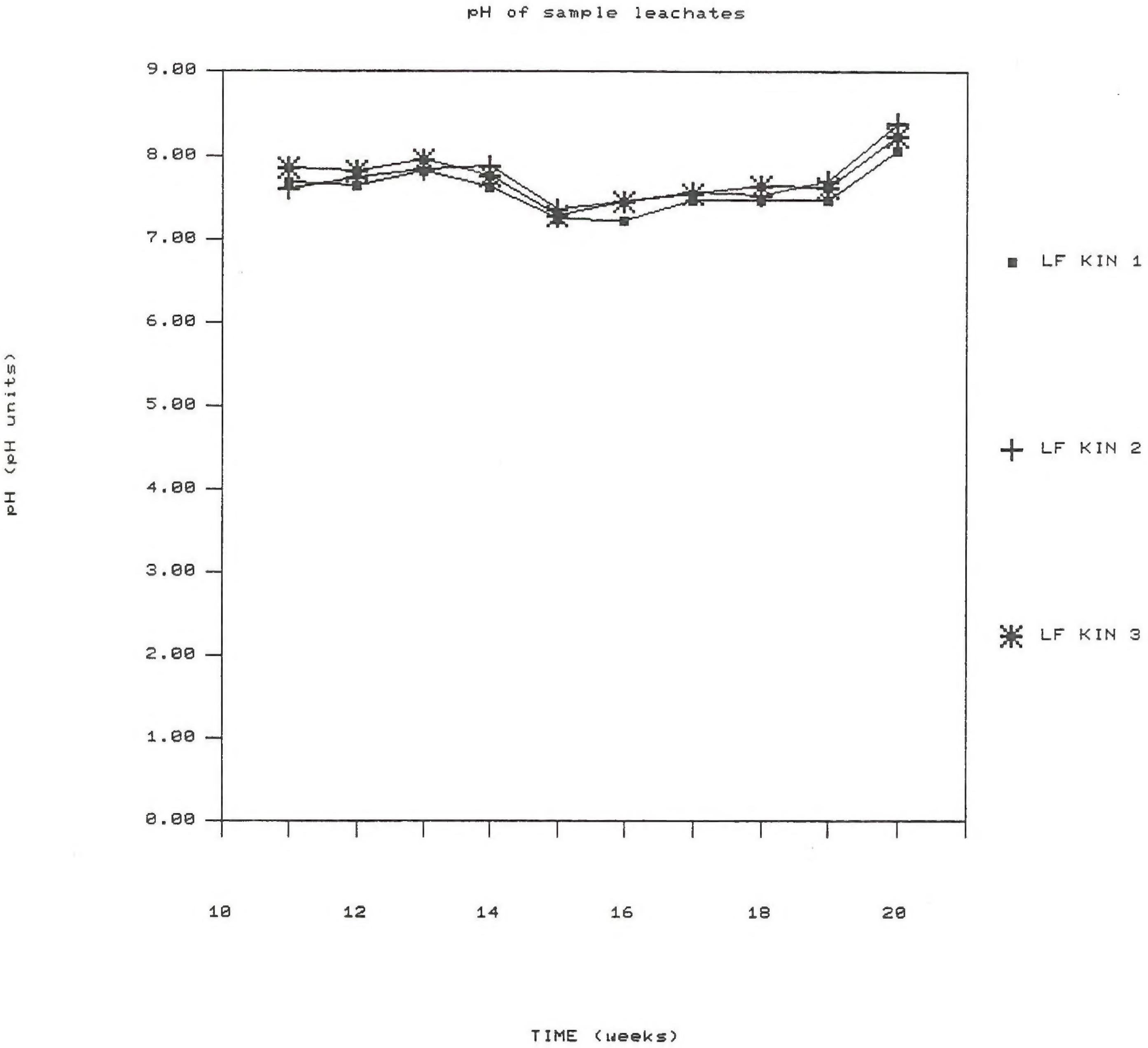


FIGURE C-17

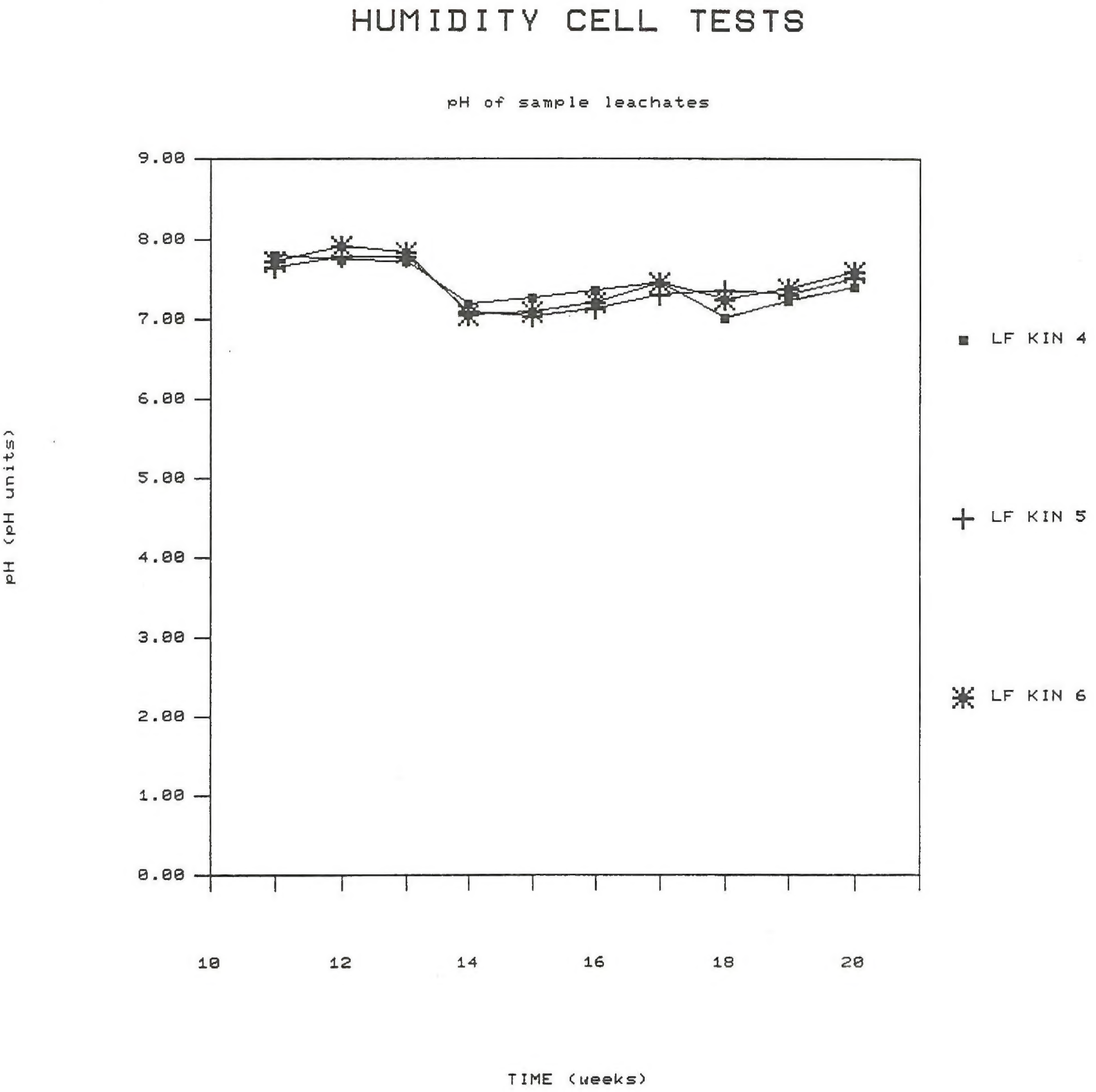

HUMIDITY CELL TESTS
pH of sample leachates
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
pH (pH units)
10
12
14
16
18
20
TIME (weeks)
■ LF KIN 4
+ LF KIN 5
✳ LF KIN 6

FIGURE C-18

HUMIDITY CELL TESTS

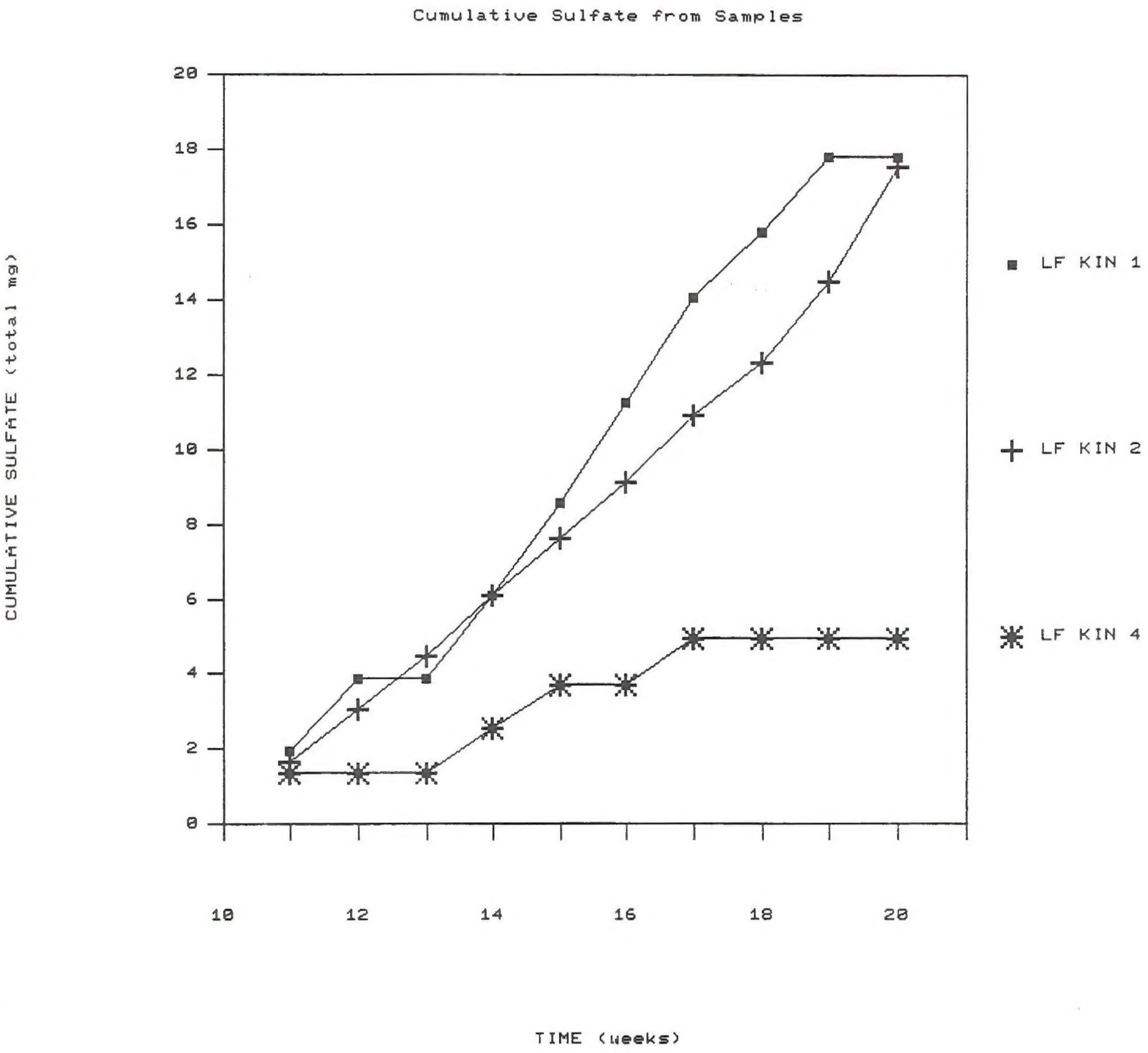
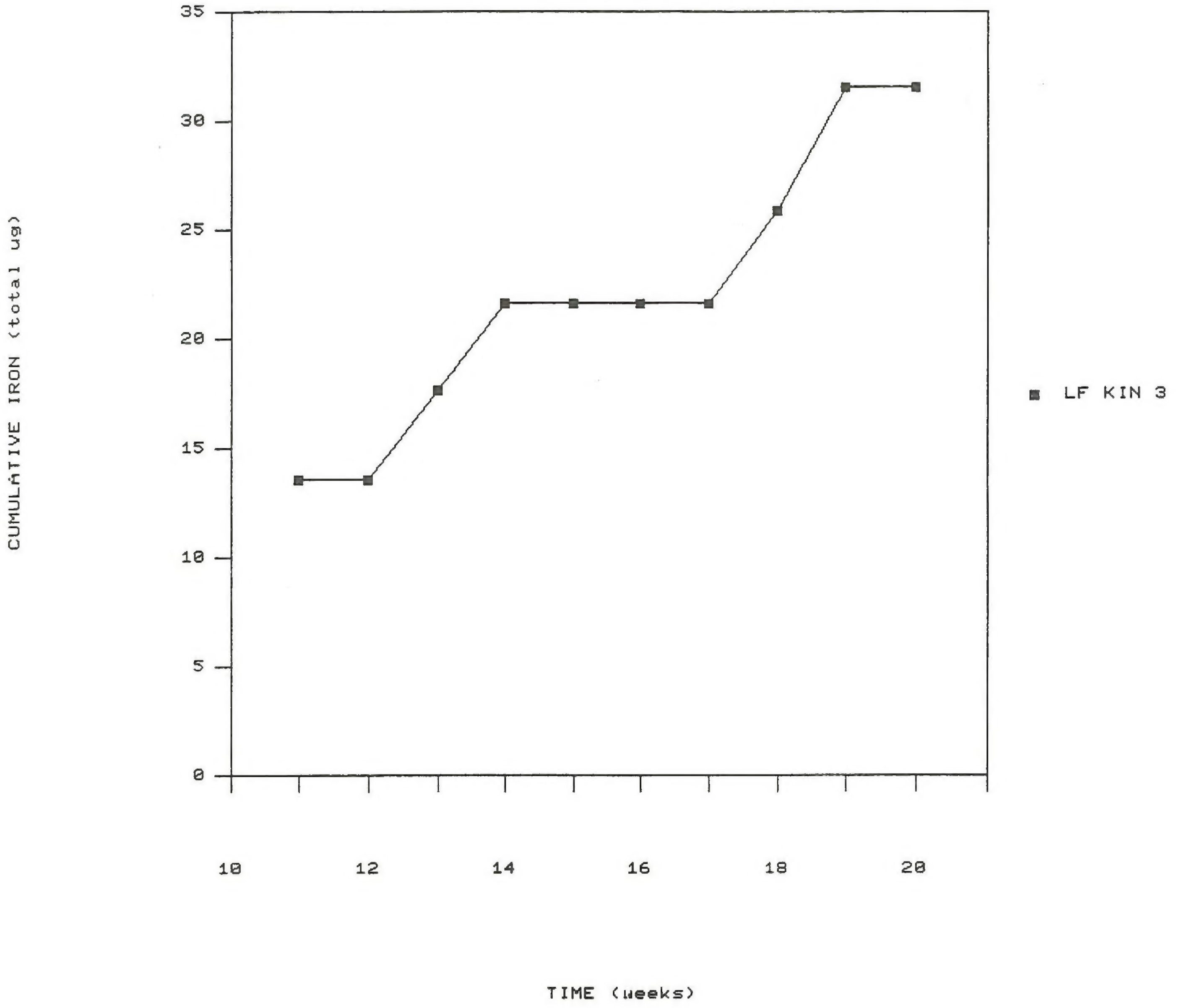


FIGURE C-19



HUMIDITY CELL TESTS

Cumulative Iron from Samples

FIGURE C-20

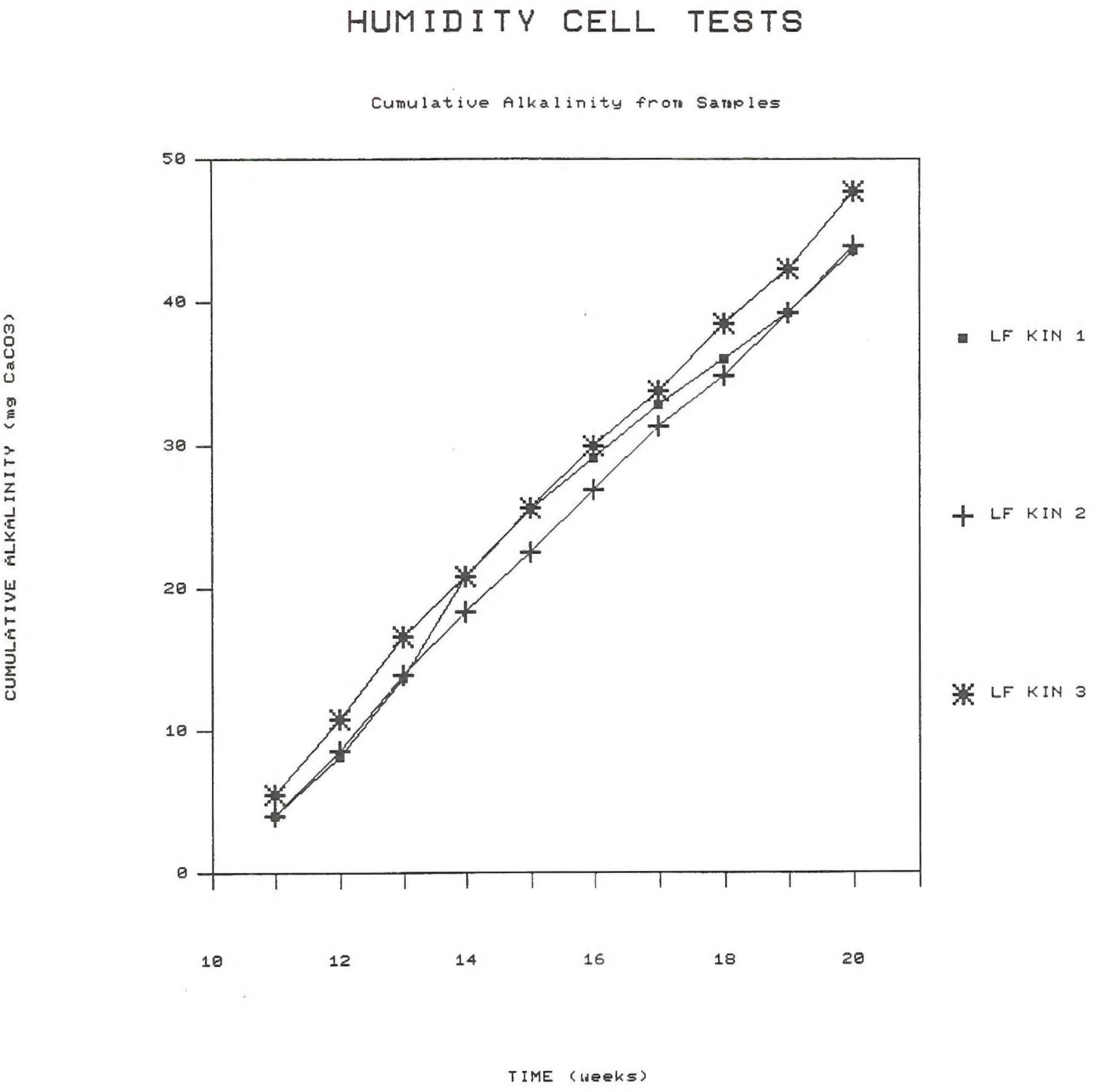
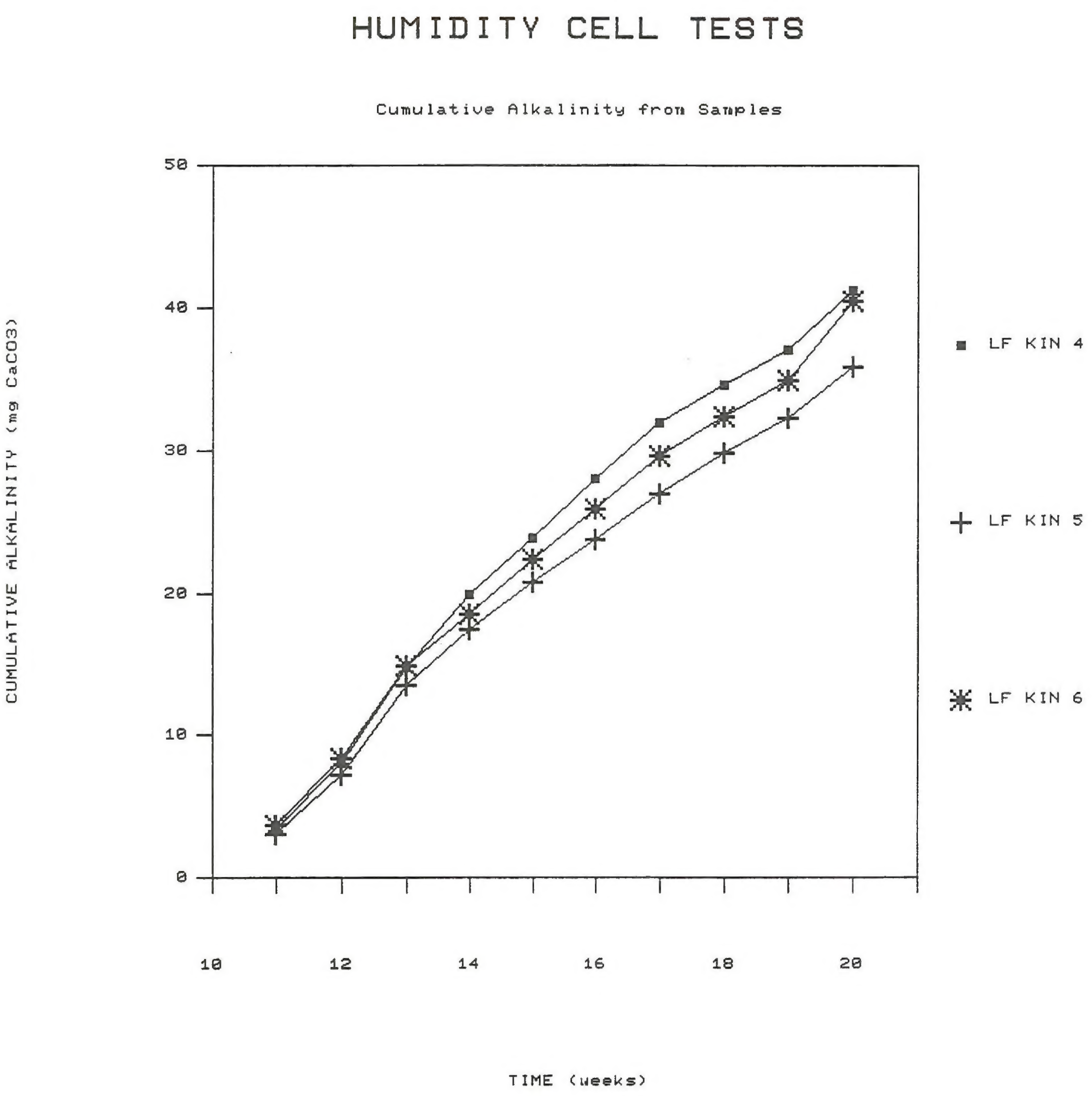

HUMIDITY CELL TESTS
Cumulative Alkalinity from Samples
CUMULATIVE ALKALINITY (mg CaCO3)
50
40
30
20
10
0
10
12
14
16
18
20
TIME (weeks)
■ LF KIN 1
+ LF KIN 2
✳ LF KIN 3

FIGURE C-21


HUMIDITY CELL TESTS
Cumulative Alkalinity from Samples
CUMULATIVE ALKALINITY (mg CaCO3)
0
10
20
30
40
50
10
12
14
16
18
20
TIME (weeks)
■ LF KIN 4
+ LF KIN 5
✳ LF KIN 6

APPENDIX C-2

WATER QUALITY MONITORING DATA - LF-1, LF-2, LF-I SPREADSHEETS

Woodward-Clyde
Engineering & sciences applied to the earth & its environment

July 13, 1994

Mr. George Brown
U.S. Bureau of Land Management
1103 N. Fancher
Spokane WA 99212-1275

Subject: Excel database tables and graphs for LF-I, LF-1, and LF-2 Lamefoot Mine Project (WCC Project 23295 Task FEIS)

Dear George:

Enclosed are disk and hard copies of the spreadsheets, graphs, and explanatory notes prepared from the water quality monitoring data from stations LF-I (infiltration pond) and wells LF-1 and LF-2 at the Lamefoot site. Important features and advantages of the tables include the following:

1. The three tables (for LF-I, LF-1, and LF-2 data) are constructed in Excel 5.0, a readily available and powerful spreadsheet program. For ease in updating the spreadsheets and plotting future graphs, the graphs have been directly linked to and produced from the data spreadsheets.

2. Spreadsheets can be readily updated by inserting lines of data and updating the calculation formulas. Graphs can be updated and replotted by including the date and concentration ranges of the new data set.

3. Spreadsheets have been set up to automatically calculate maxima, minima, averages, and whether a parameter equals or exceeds state groundwater criteria.

4. Complete notes have been included on abbreviations used in the tables and assumptions used for calculations and graphs.

Key (indicator) parameters which are included in the tables include field pH, lab pH, field specific conductivity, lab specific conductivity, total alkalinity, arsenic, copper, iron, lead, manganese, zinc, sulfate, nitrate, total dissolved solids, and total suspended solids. Three parameters originally proposed are not included (aluminum, barium, and cadmium), because they were not on the short list of parameters to be monitored most

23295/LE19 07-13-94(3:59pm)/RPT/5

frequently in the future. Where data sets of more than two points were available, graphs were constructed to display field pH; field specific conductivity; total alkalinity; total recoverable or dissolved iron, manganese, and zinc; sulfate; nitrate; and total dissolved solids.

We hope these spreadsheets will be useful in your discussions Friday and in monitoring future activities at the site. Please do not hesitate to call us if you have further questions. If you wish, we can arrange for your staffers who will be updating the spreadsheets and graphs to talk with the WCC staffers who constructed them.

Yours sincerely,

Sandra Lewellen Jones

Scott Mernitz
Project Manager

Sandra Lewellen Jones
Assistant Project Scientist

SJ:slj

(1 copy sent)

Enclosures

1c: Mr. Walt Hunt, Echo Bay Minerals Co.
    Chris Paulsen
    Bob Moran
    Mark Zuber
    Andre Fiedler
    Project File 23295 FEIS

SUMMARY OF SELECTED WATER QUALITY DATA
LAMEFOOT MINE INFILTRATION POND (LF-I)

Sample ID: LF-I	Field Parameters			Laboratory Analytical Parameters								
	Field pH (units)	Field SC (μmhos/cm)	Field Temp. °C	Lab pH (units)	Lab SC (μmhos/cm)	As-T (mg/L)	As-D (mg/L)	Cu-T mg/L)	Cu-D (mg/L)	Fe-T (mg/L)	Fe-D (mg/L)	Pb-T (mg/L)
State GW Criteria:	6.5-8.5					0.05		1.0		0.30		0.05
4/6/93	8.2	1572	6.0	7.9	1430	< 0.04		0.011		3.17		< 0.04
5/11/93	8.1	1420	9.0	7.56	1330			0.035				< 0.04
6/8/93	7.7	1651	20	7.17				0.014				< 0.04
7/7/93	7.9	1450	19	7.29	1400				0.008			
8/5/93	7.8	1510	23	6.83	1520			0.019				< 0.04
9/15/93	8.1	1546	16					0.02				< 0.02
10/6/93	8.2	1542	13					0.01				< 0.02
11/2/93	7.9	2310	5.0	8.3	2150				< 0.01			
4/6/94	7.9	1313	10					0.05				< 0.02
5/10/94	8.0	1111	12					0.04				< 0.02
Summary Statistics:												
LF-I Maximum	8.2	2310	23	8.3	2150	0.04		0.05	0.01	3.17		0.04
LF-I Minimum	7.7	1111	5	6.83	1330	0.04		0.01	0.008	3.17		0.02
LF-I Average	8.0	1543	13.3	7.5	1566	0.04		0.02	0.009	3.17		0.03
n	10	10	10	6	5	1		8	2	1		8
≥State GW Criteria?	NO					NO		NO		YES		NO

(1) Total $NO_3 + NO_2$ - N
(2) Dissolved NO_3-N

Notes: LF-I dry or frozen and not sampled: Dec. 93, Jan. 94, Feb. 94, Mar. 94

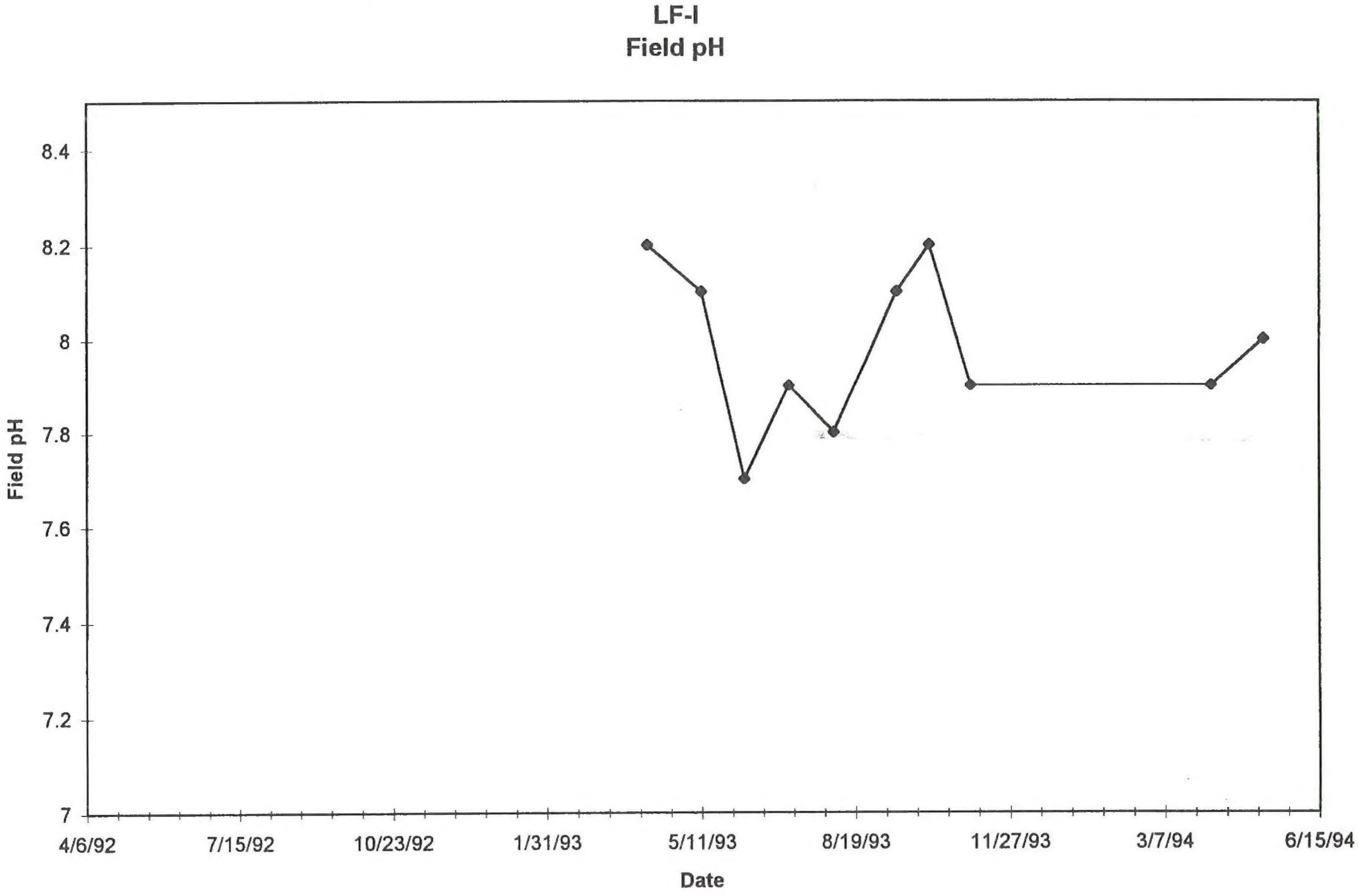
SUMMARY OF SELECTED WATER QUALITY DATA
LAMEFOOT MINE INFILTRATION POND (LF-I)

Sample ID: LF-I	Laboratory Analytical Parameters									
	Pb-D (mg/L)	Mn-T (mg/L)	Mn-D (mg/L)	Zn-T (mg/L)	Zn-D (mg/L)	Total Alk. As CaCO$_3$ (mg/L)	Sulfate (mg/L)	NO$_3$ As N (mg/L)	TDS (mg/L)	TSS (mg/L)
State GW Criteria:		0.05		5.0			250	10	500	
4/6/93		0.112		0.038				70.5		91.4
5/11/93				0.165				33.3		358
6/8/93				0.035				61.7 (1)		182
7/7/93	< 0.04				0.033			54 (1)		17.9
8/5/93				0.075				1.63		15.6
9/15/93				0.05				64.4 (2)		18
10/6/93				0.06				59.8 (2)		82
11/2/93	< 0.02		0.05		0.03	208	545	136 (2)	978	< 2
4/6/94				0.05				24.04 (2)		
5/10/94				0.04				11.74 (2)		
Summary Statistics:										
LF-I Maximum	0.04	0.112	0.05	0.165	0.033	208	545	136	978	358
LF-I Minimum	0.02	0.112	0.05	0.035	0.030	208	545	1.63	978	2
LF-I Average	0.03	0.112	0.05	0.064	0.032	208	545	51.7	978	95.9
n	2	1	1	8	2	1	1	10	1	8
≥State GW Criteria?		YES		NO			YES	YES	YES	

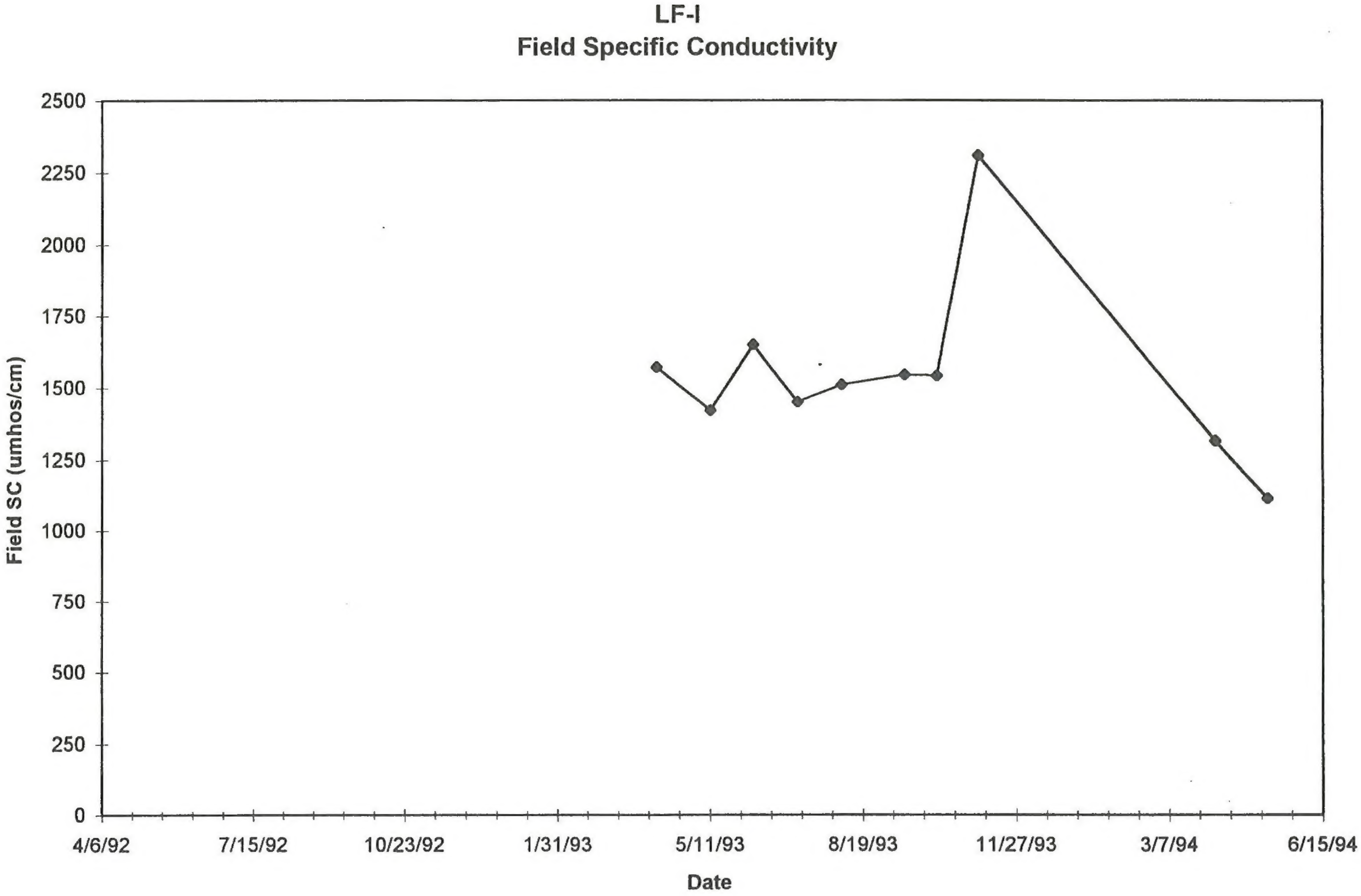
(1) Total NO$_3$ + NO$_2$ - N

(2) Dissolved NO$_3$-N

Notes: LF-I dry or frozen and not sampled: Dec. 93, Jan. 94, Feb. 94, Mar. 94

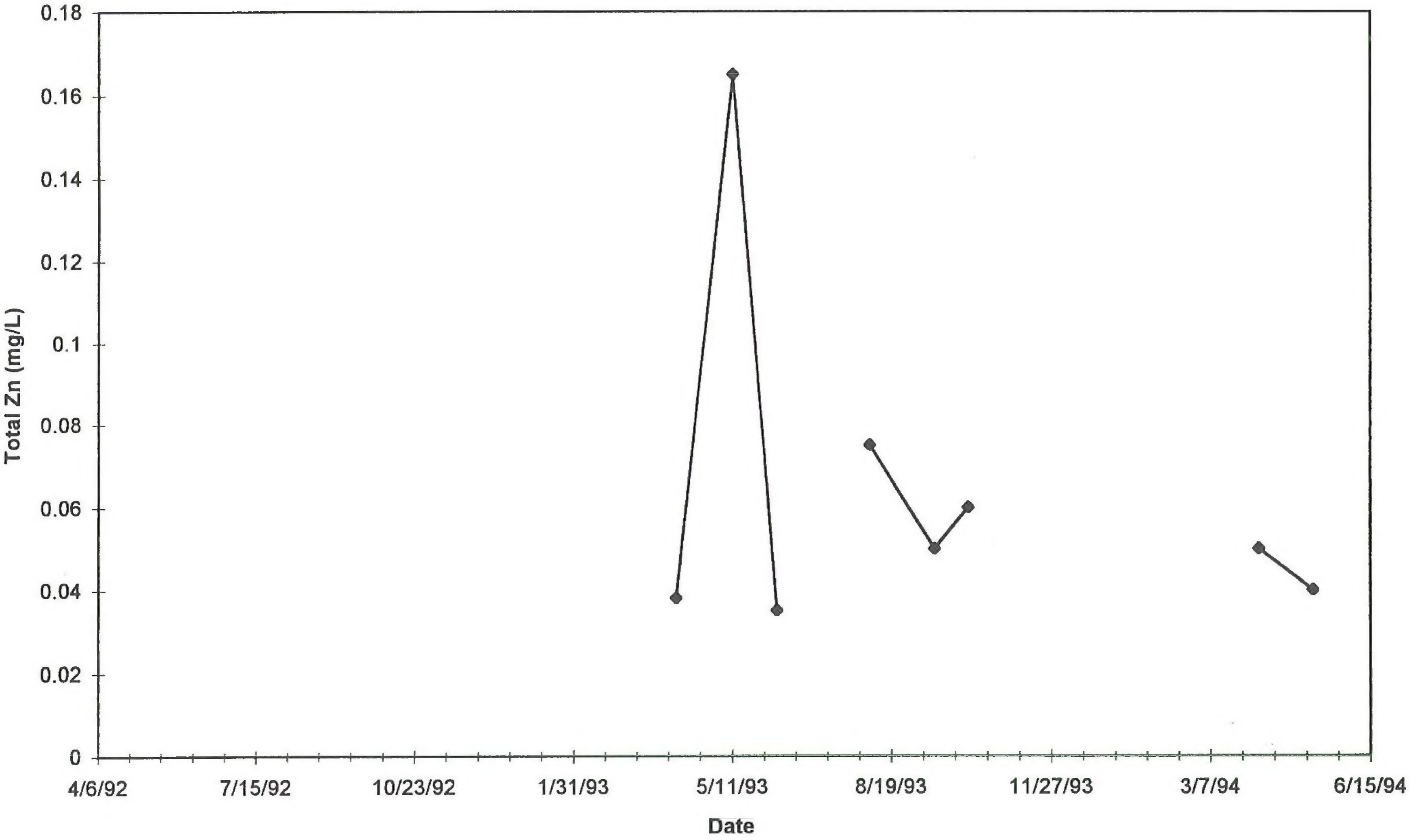

LF-I
Field pH
8.4
8.2
8
7.8
7.6
7.4
7.2
7
Field pH
4/6/92
7/15/92
10/23/92
1/31/93
5/11/93
8/19/93
11/27/93
3/7/94
6/15/94
Date

LFIpH.xls

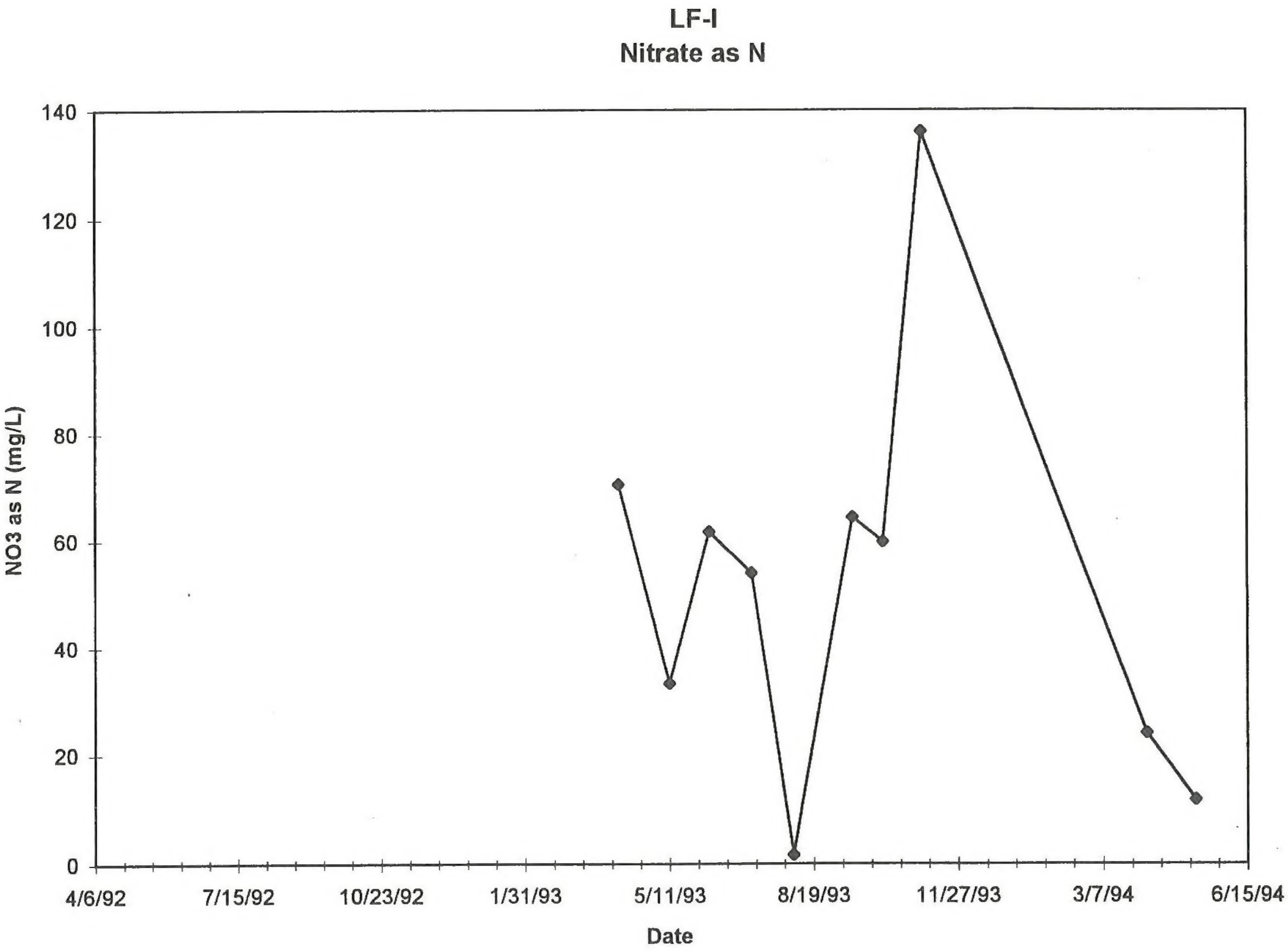

LF-I
Field Specific Conductivity
Field SC (umhos/cm)
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
4/6/92
7/15/92
10/23/92
1/31/93
5/11/93
8/19/93
11/27/93
3/7/94
6/15/94
Date

LFISC.xls

LF-I
Total Zinc



LFITOTZn.xls


LF-I
Nitrate as N
NO3 as N (mg/L)
0
20
40
60
80
100
120
140
4/6/92
7/15/92
10/23/92
1/31/93
5/11/93
8/19/93
11/27/93
3/7/94
6/15/94
Date

LFINO3.xls

SUMMARY OF SELECTED WATER QUALITY DATA
LAMEFOOT MINE MONITORING WELL LF-1

Sample ID:	Field Parameters			Laboratory Analytical Parameters								
LF-1	Field pH (units)	Field SC (μmhos/cm)	Field Temp. °C	Lab pH (units)	Lab SC (μmhos/cm)	As-T (mg/L)	As-D (mg/L)	Cu-T mg/L)	Cu-D (mg/L)	Fe-T (mg/L)	Fe-D (mg/L)	Pb-T (mg/L)
State GW Criteria:	6.5-8.5					0.05		1.0		0.30		0.05
4/7/92	7.9	921	5.0	7.72	806		0.026		< 0.005		0.04	
5/5/92	7.8	906	5.0	8.02	769		0.047		< 0.005		0.09	
6/9/92	7.7	892	6.0	7.76	798		< 0.04		0.006		1.48	
7/8/92	7.8	902	6.0	8.08	793		< 0.002		0.056		0.12	
10/14/92	7.7	910	5.0	8	865		0.065		0.076		22.8	
11/10/92	7.8	906	4.0	7.8	826		< 0.04		0.005		0.584	
12/2/92	7.8	946	4.0	8.07	897		< 0.05		< 0.004		0.056	
1/5/93	7.3	902	4.0	8	862		0.04		0.004		0.124	
2/3/93	7.1	1005	6.0	7.8	851		< 0.04		< 0.003		< 0.009	
3/2/93	7.4	945	6.3	7.84	810		< 0.04		< 0.003		< 0.009	
4/6/93	8.2	759	7.0	7.9	717		< 0.04		< 0.004		0.018	
5/11/93	7.8	960	10	7.72	765		< 0.04		< 0.004		< 0.009	
6/8/93	7.7	831	9.0	7.98	800		< 0.04		< 0.004		< 0.009	
7/7/93	7.6	838	10	7.57	779		< 0.04		< 0.001		< 0.02	
8/5/93	7.7	740	12	7.64	772		< 0.04		0.002		< 0.02	
9/14/93	8.1	788	10	8.1	769		0.008		< 0.01			
10/6/93	7.8	835	10	7.3	755		0.007		< 0.01			
11/2/93	7.7	852	9.0	8.1	782		0.008		< 0.01			
12/7/93	7.0	871	7.8	8.2	784		0.007		< 0.01			
2/8/94	7.7	780	4.0	7.7	800		0.006		< 0.05			
3/8/94	7.7	857	9.0	8.1	791		0.007		< 0.01			
4/6/94	7.4	781	10	7.8	766		0.006		< 0.01			
5/10/94	7.5	798	8.0	7.8	782		0.006		< 0.01			
Summary Statistics:												
LF-1 Maximum	8.2	1005	12	8.2	897		0.065		0.076		22.8	
LF-1 Minimum	7	740	4	7.3	717		0.002		0.001		0.009	
LF-1 Average	7.7	866	7.3	7.9	797		0.028		0.013		1.693	
n	23	23	23	23	23		23		23		15	
≥State GW Criteria?	NO						YES (3)		NO (3)		YES (3)	

(1) Total $NO_3 + NO_2$ - N

(2) Dissolved NO_3 - N

(3) Dissolved concentration compared to GW criteria for total metals

23295/LF-1.XLS 7/14/94(2:01 PM)/RPT/5

Sheet 1 of 2

SUMMARY OF SELECTED WATER QUALITY DATA
LAMEFOOT MINE MONITORING WELL LF-1

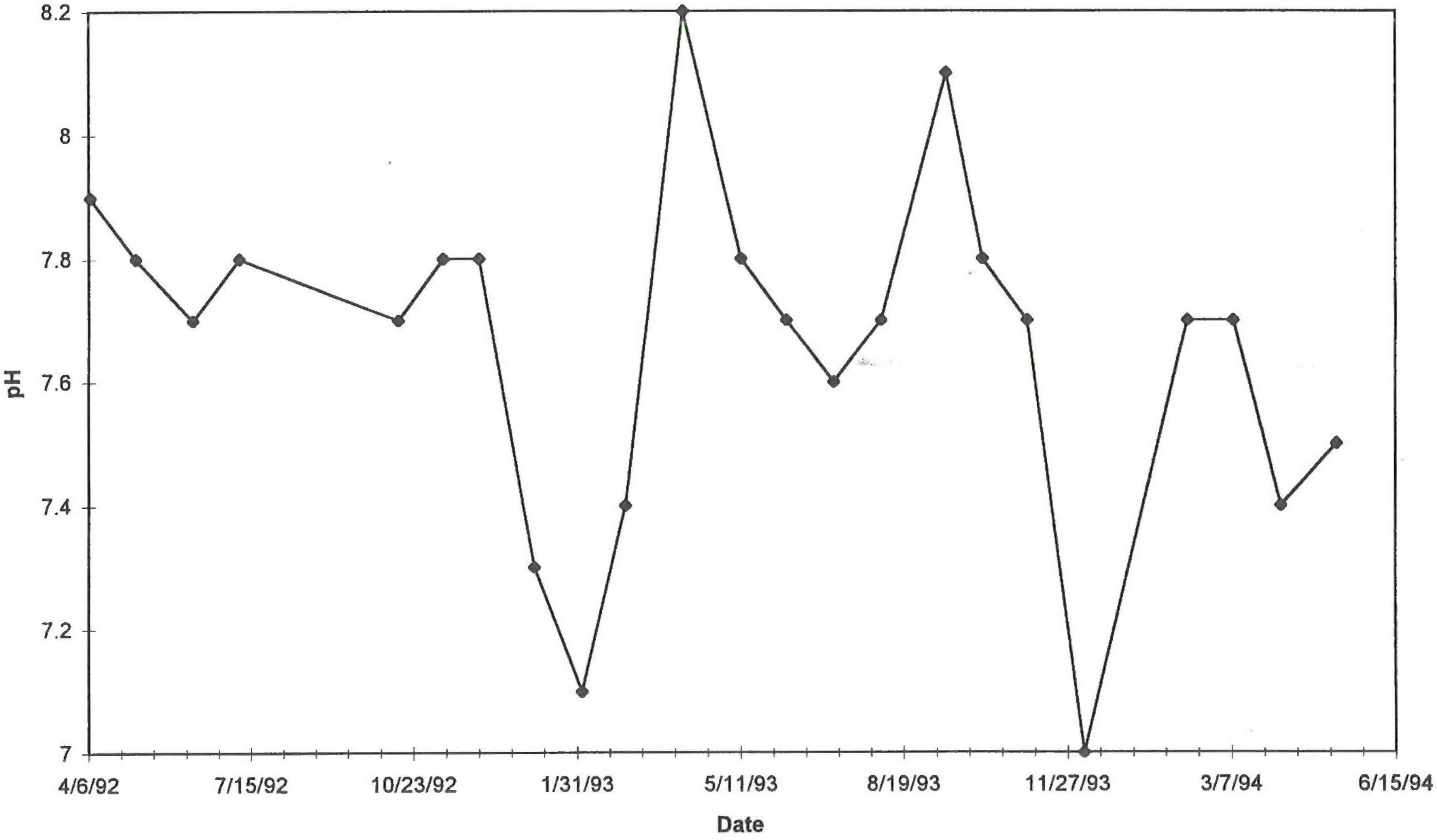
Sample ID: LF-1	Laboratory Analytical Parameters									
	Pb-D (mg/L)	Mn-T (mg/L)	Mn-D (mg/L)	Zn-T (mg/L)	Zn-D (mg/L)	Total Alk. as $CaCO_3$ (mg/L)	Sulfate (mg/L)	NO_3 As N (mg/L)	TDS (mg/L)	TSS (mg/L)
State GW Criteria:		0.05		5.0			250	10	500	
4/7/92	< 0.001		< 0.001		0.006	254	203	0.59 (1)	552	863
5/5/92	0.019		0.004		< 0.005	247	214	0.99	544	50.9
6/9/92	< 0.04		0.028		0.021	234	211	0.87 (1)	616	292.5
7/8/92	< 0.001		0.007		0.016	246	189	0.74	521	53
10/14/92	< 0.049		0.458		0.13	274	218.3	0.66 (1)	610	434.7
11/10/92	0.1		0.027		0.014	266	224	0.66 (1)	629	1737.3
12/2/92	< 0.05		0.006		0.003	281	226	0.69 (1)	572	310
1/5/93	0.08		< 0.002		0.009	282	218	1.99 (1)	571	453
2/3/93	< 0.03		< 0.002		0.021	271	221	0.58 (1)	619	357
3/2/93	< 0.03		< 0.002		0.015	270	204	0.93 (1)	578	327
4/6/93	< 0.04		< 0.001		0.003	256	154	1.28 (1)	474	111
5/11/93	< 0.04		< 0.001		0.003	240	181	1.27 (1)	455	58.6
6/8/93	< 0.04		< 0.001		< 0.001	246	188	0.93 (1)	531	186
7/7/93	< 0.04		< 0.002		< 0.002	255	192	0.89 (1)	547	34.2
8/5/93	< 0.04		< 0.002		< 0.002	261	181	0.86 (1)	553	63
9/14/93	< 0.02		0.07		< 0.01	264	179	0.87 (2)	510	160
10/6/93	< 0.02		< 0.01		0.02	282	177	0.77 (2)	526	26
11/2/93	< 0.02		< 0.01		< 0.01	270	200	0.7 (2)	554	8
12/7/93	< 0.02		< 0.01		< 0.01	262	179	0.68 (2)	490	< 2
2/8/94	< 0.1		< 0.05		< 0.05	284	173	0.69 (2)	542	< 2
3/8/94	< 0.02		< 0.01		< 0.02	274	163	0.88 (2)	520	2
4/6/94	< 0.02		< 0.01		< 0.01	258	152	1.07 (2)	478	10
5/10/94	< 0.02		< 0.01		< 0.01	278	187	1.11 (2)	492	< 2
Summary Statistics:										
LF-1 Maximum	0.1		0.458		0.13	284	226	1.99	629	1737.3
LF-1 Minimum	0.001		0.001		0.001	234	152	0.58	455	2
LF-1 Average	0.037		0.031		0.017	263	193	0.90	543	241
	23		23		23	23	23	23	23	23
≥State GW Criteria?	YES (3)		YES (3)		NO (3)		YES	YES	YES	

(1) $NO_3 + NO_2$ - N

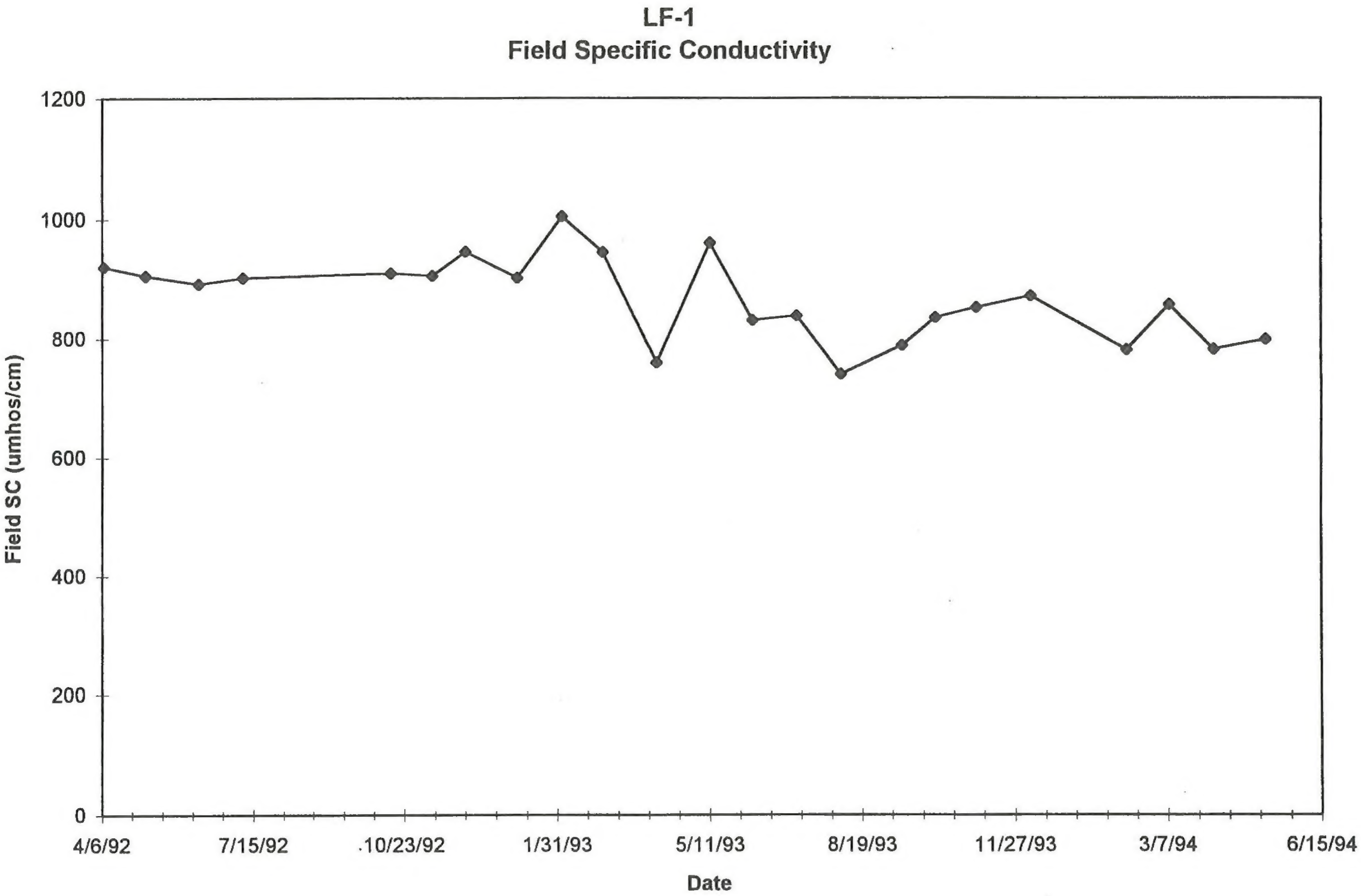
(2) Dissolved NO_3 - N

(3) Dissolved concentration compared to GW criteria for total metals

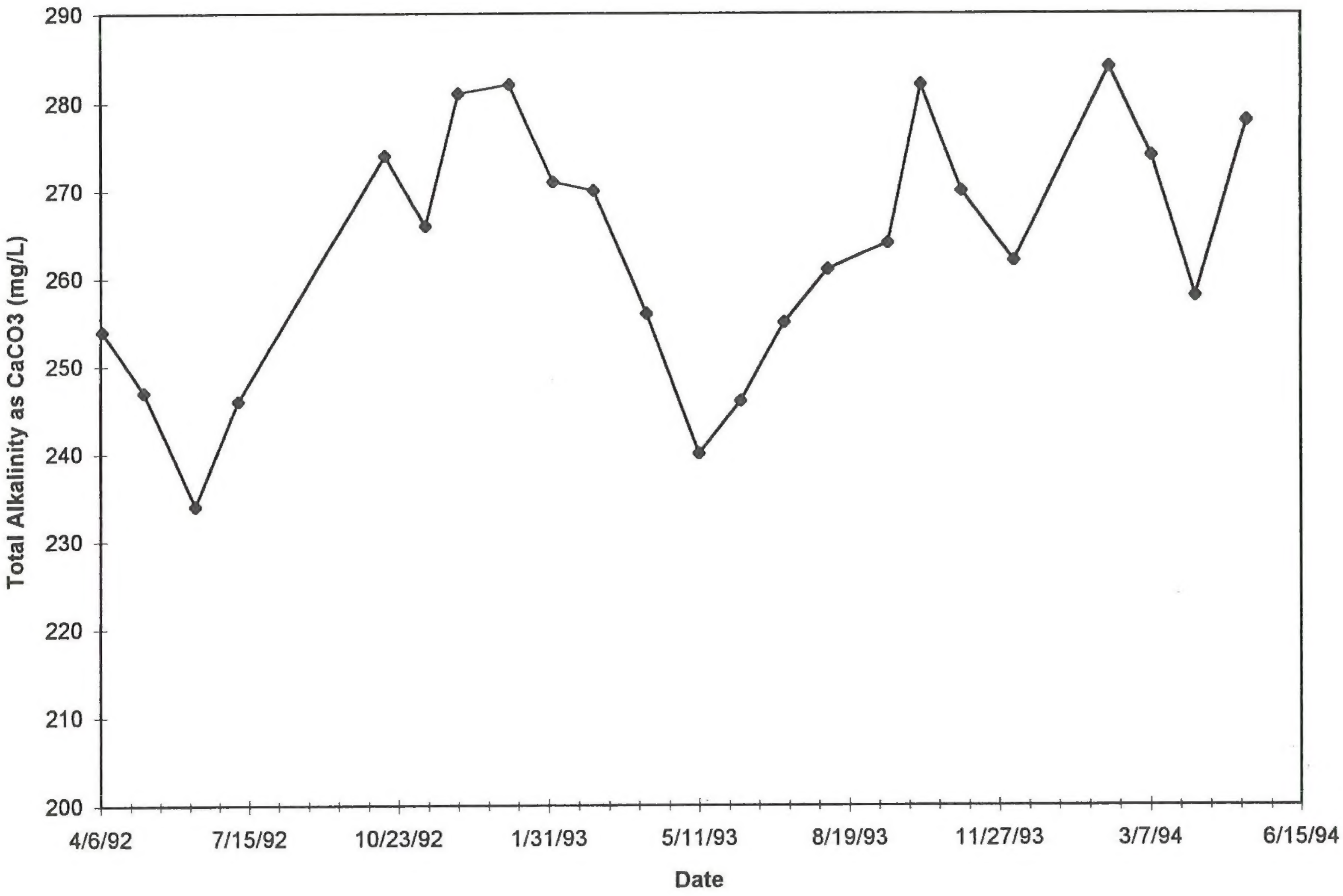
LF-1
Field pH



LF1pH.xls


LF-1
Field Specific Conductivity
Field SC (umhos/cm)
1200
1000
800
600
400
200
0
4/6/92
7/15/92
10/23/92
1/31/93
5/11/93
8/19/93
11/27/93
3/7/94
6/15/94
Date

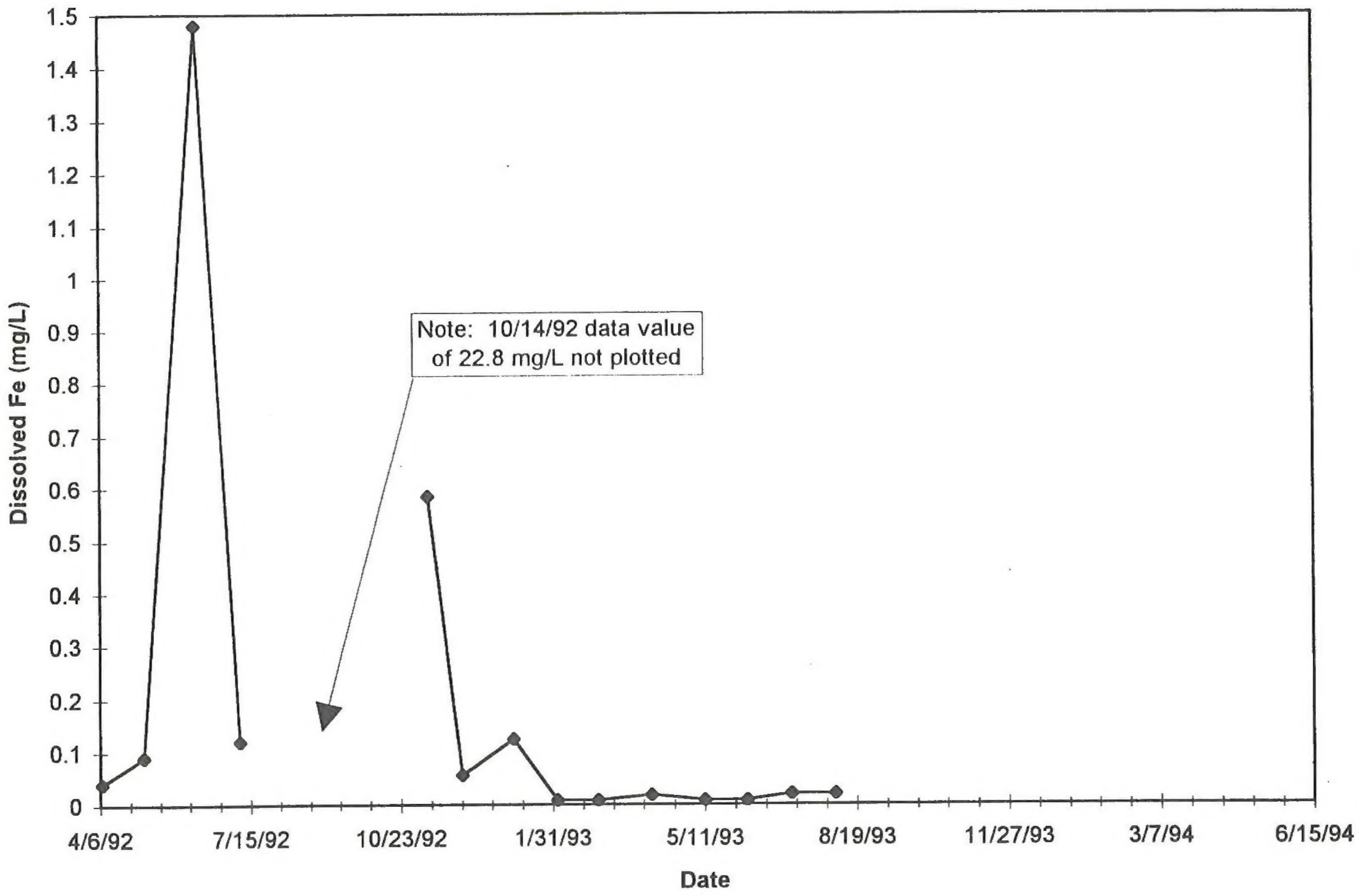
LF1SC.xls



LF-1
Total Alkalinity

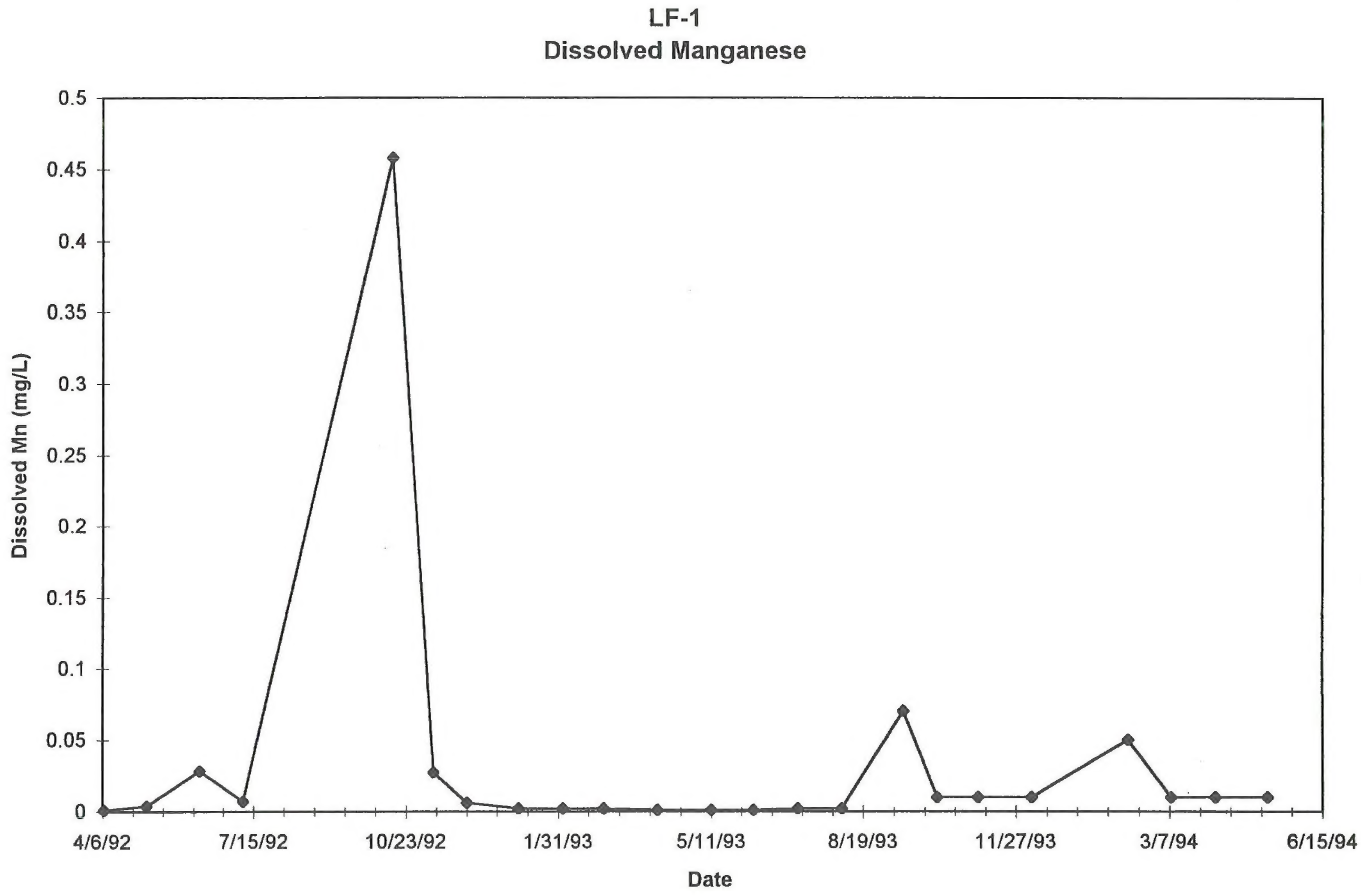
LF1TotAlk.xls

LF-1
Dissolved Iron

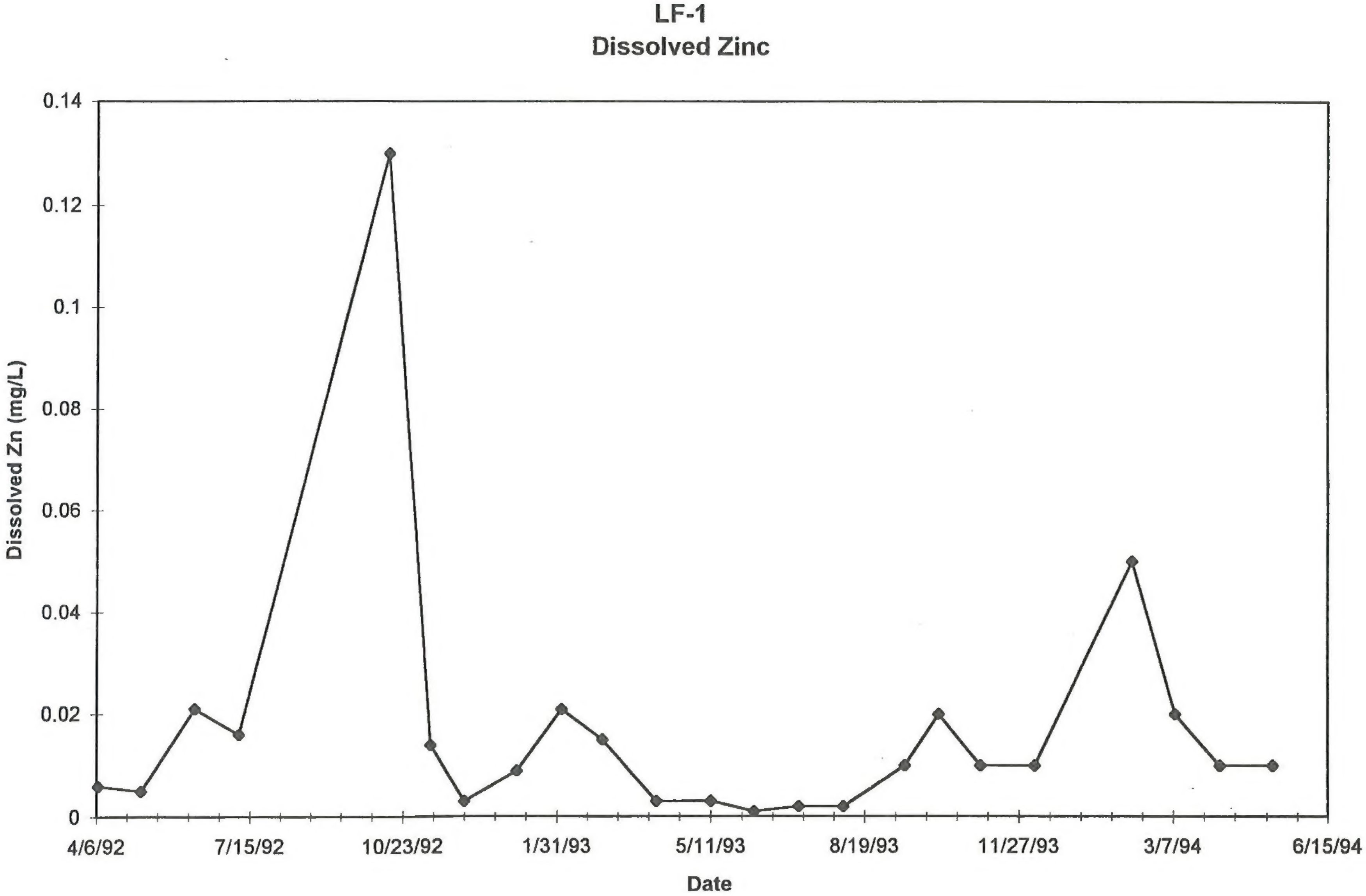


Note: 10/14/92 data value of 22.8 mg/L not plotted

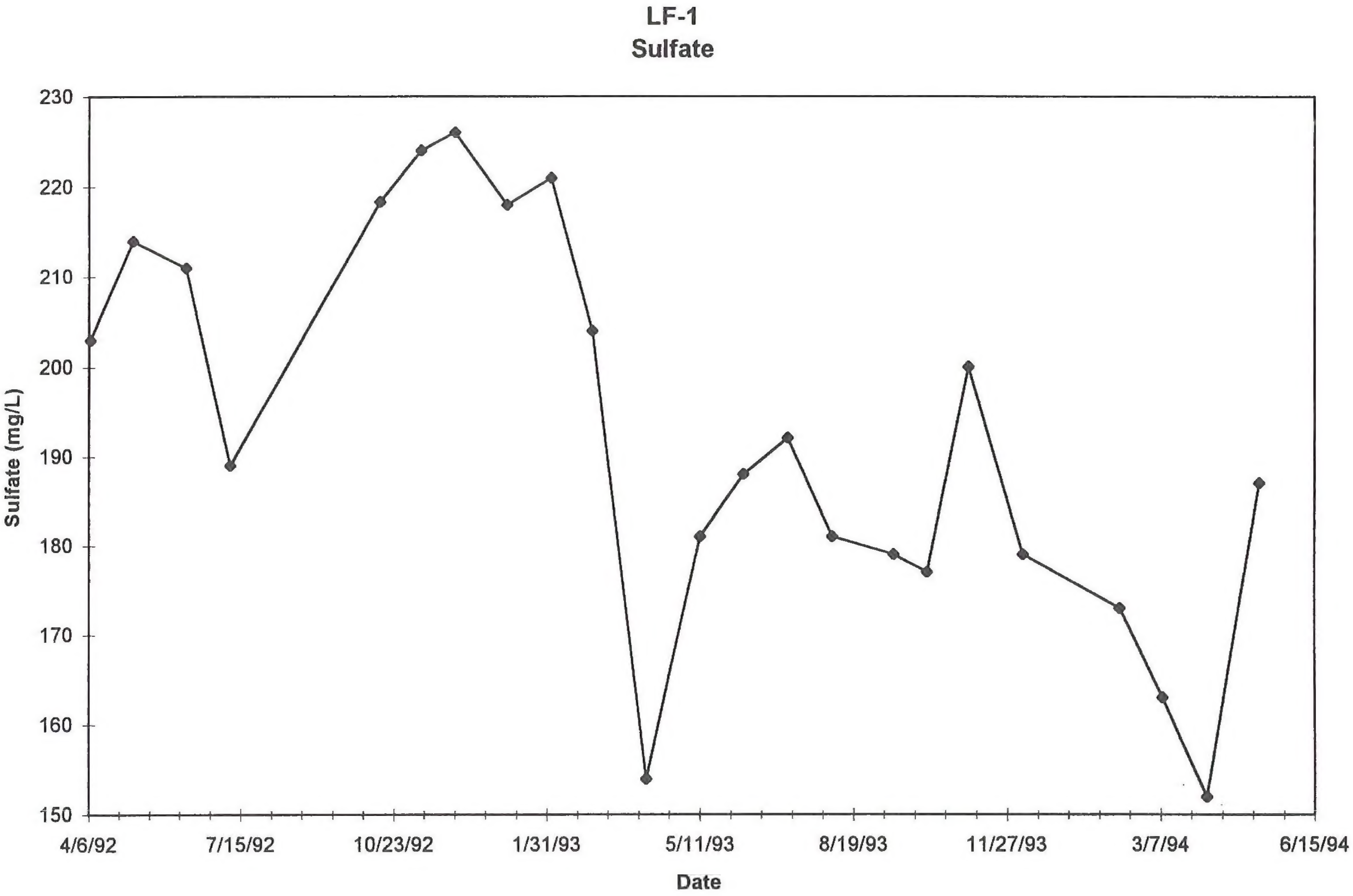
LF1DisFe.xls



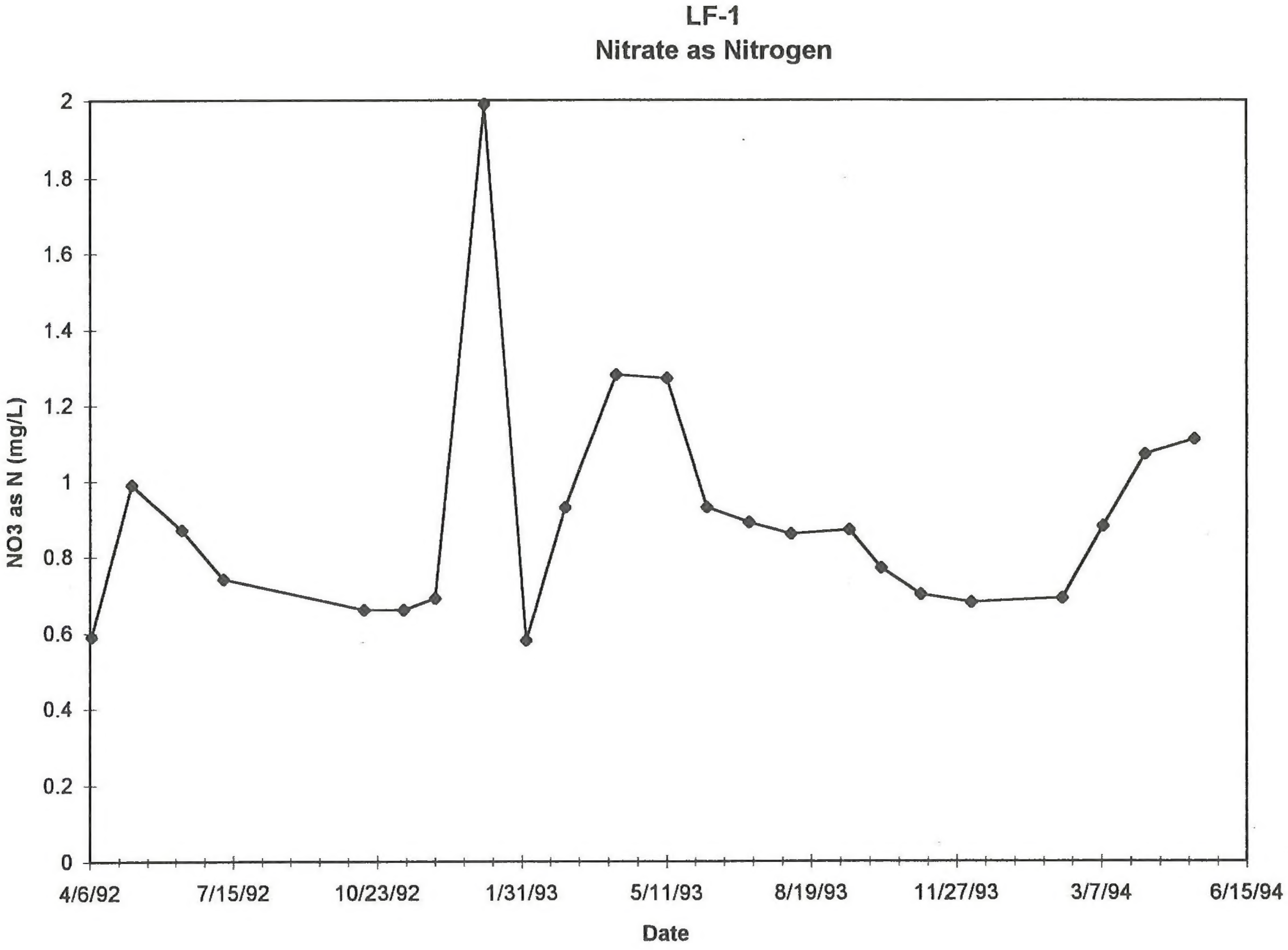
LF1DisMn.xls



LF1DisZn.xls

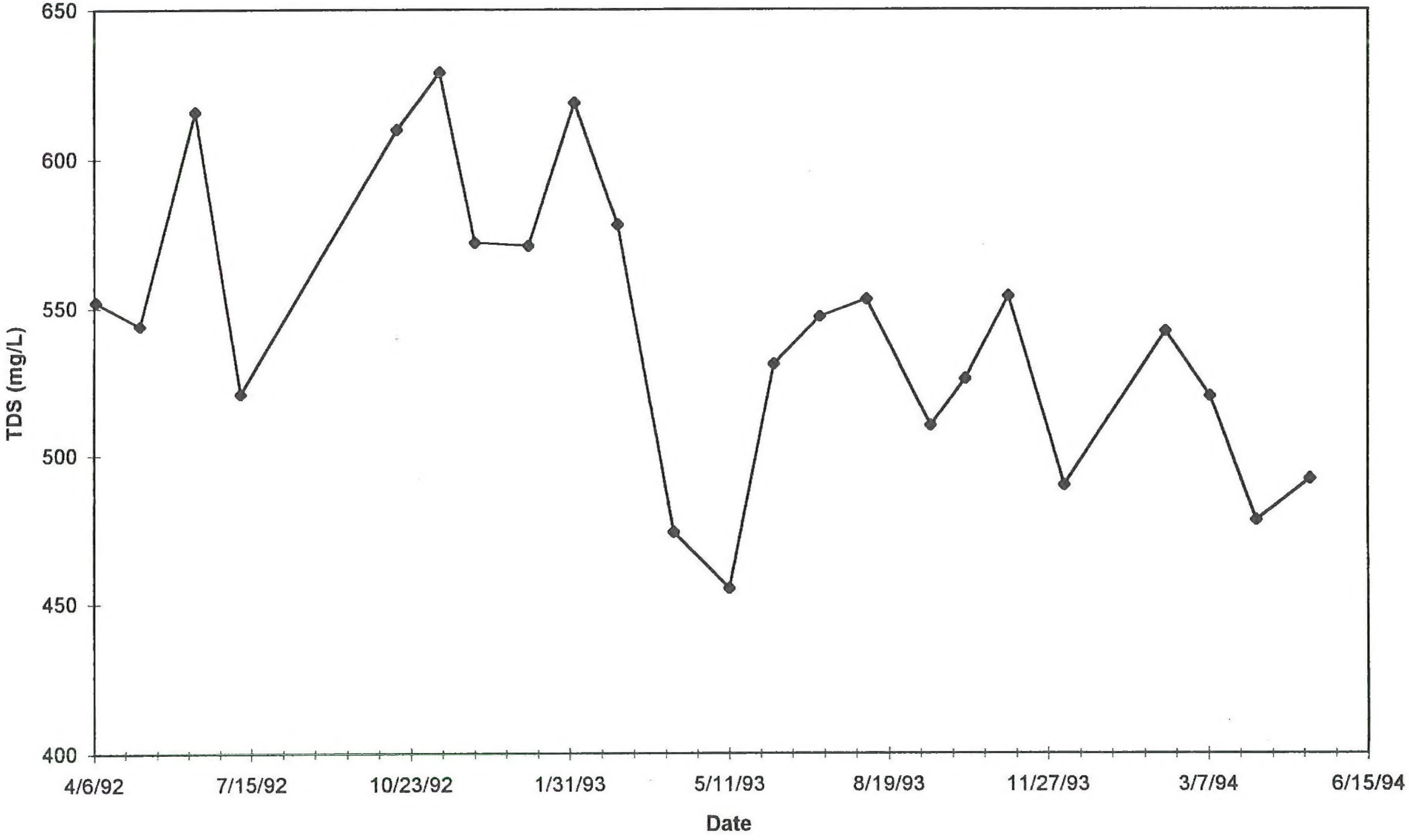

LF-1
Sulfate
Sulfate (mg/L)
230
220
210
200
190
180
170
160
150
4/6/92
7/15/92
10/23/92
1/31/93
5/11/93
8/19/93
11/27/93
3/7/94
6/15/94
Date

LF1Slf.xls


LF-1
Nitrate as Nitrogen
NO3 as N (mg/L)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
4/6/92
7/15/92
10/23/92
1/31/93
5/11/93
8/19/93
11/27/93
3/7/94
6/15/94
Date

LF1NO3.xls

LF-1
Total Dissolved Solids



LF1TDS.xls

SUMMARY OF SELECTED WATER QUALITY DATA
LAMEFOOT MINE MONITORING WELL LF-2

Sample ID:	Field Parameters			Laboratory Analytical Parameters									
LF-2	Field pH (units)	Field SC (µmhos/cm)	Field Temp. °C	Lab pH (units)	Lab SC (µmhos/cm)	As-T (mg/L)	As-D (mg/L)	Cu-T mg/L)	Cu-D (mg/L)	Fe-T (mg/L)	Fe-D (mg/L)	Pb-T (mg/L)
State GW Criteria:	6.5-8.5					0.05		1.0		0.30		0.05
4/7/92	7.8	1170	5.0	7.89	1078		< 0.002		0.009		0.04	
5/5/92	7.7	1100	5.0	7.89	955		0.033		0.007		0.6	
6/9/92	7.4	1040	6.0	7.65	904		< 0.04		0.006		0.43	
7/8/92	7.5	1110	6.0	8.0	994		< 0.002		0.007		0.16	
8/5/92	7.6	1096	6.0	7.85	955		< 0.035		0.005		0.65	
9/8/92	7.5	1020	7.0	7.88	1020		0.035		< 0.005		0.04	
10/14/92	7.6	1000	5.0	8.0	976		0.108		0.213		48.4	
11/10/92	7.7	1040	5.0	7.8	956		< 0.04		0.005		0.183	
12/2/92	7.5	1100	5.0	7.8	1010		< 0.05		< 0.004		0.083	
1/5/93	7.3	1105	4.0	7.7	1030		< 0.04		0.004		0.088	
2/3/93	7.1	1180	6.0	7.7	1010		< 0.04		< 0.003		< 0.009	
3/2/93	7.4	1195	7.0	7.78	1028		< 0.04		0.004		< 0.009	
4/6/93	8.2	1106	7.9	7.96	1050		< 0.04		< 0.004		0.022	
5/11/93	7.6	1180	10	7.7	848		< 0.04		< 0.004		< 0.009	
6/8/93	7.7	795	9.0	7.9	749		< 0.04		0.006		< 0.009	
7/7/93	7.6	838	10	7.53	762		< 0.04		0.004		< 0.02	
8/5/93	7.7	646	11	7.19	807		< 0.04		0.004		< 0.02	
9/14/93	8.1	805	9.0	8.1	822		0.006		0.01			
10/6/93	7.7	967	9.0	7.6	877		0.005		< 0.01			
11/2/93	7.6	1042	8.0	8.0	968		0.005		< 0.01			
12/7/93	7	956	7.7	8.2	873		0.005		< 0.01			
2/8/94	7.6	881	5.0	7.6	900		0.007		< 0.01			
3/8/94	7.8	1038	8.0	8.0	967		0.006		< 0.01			
4/6/94	7.4	989	10	7.7	967		0.004		< 0.01			
5/10/94	7.4	767	8.0	7.6	770		0.004		< 0.01			
Summary Statistics:												
LF-2 Maximum	8.2	1195	11	8.2	1078		0.108		0.213		48.4	
LF-2 Minimum	7	646	4	7.19	749		0.002		0.003		0.009	
LF-2 Average	7.6	1007	7.2	7.8	931		0.028		0.015		2.987	
n	25	25	25	25	25		25		25		17	
≥State GW Criteria?	NO						YES (3)		NO (3)		YES (3)	

(1) Total $NO_3 + NO_2$ - N

(2) Dissolved NO_3-N

(3) Dissolved concentration compared to GW criteria for total metals

Notes: Well inaccessible and not sampled: Jan. 94

SUMMARY OF SELECTED WATER QUALITY DATA
LAMEFOOT MINE MONITORING WELL LF-2

Sample ID: LF-2	Laboratory Analytical Parameters									
	Pb-D (mg/L)	Mn-T (mg/L)	Mn-D (mg/L)	Zn-T (mg/L)	Zn-D (mg/L)	Total Alk. As $CaCO_2$ (mg/L)	Sulfate (mg/L)	NO_3 As N (mg/L)	TDS (mg/L)	TSS (mg/L)
State GW Criteria:		0.05		5.0			250		500	
4/7/92	< 0.001		0.002		0.025	292	335	0.52 (1)	799	103.2
5/5/92	0.002		0.021		0.013	264	319	0.55 (1)	776	1658
6/9/92	< 0.04		0.006		0.01	270	267	0.47 (1)	691	1750
7/8/92	< 0.001		0.009		0.019	287	286	0.48 (1)	699	585.6
8/5/92	< 0.041		0.012		0.011	259		0.4 (1)	1414	3096
9/8/92	0.012		0.002		0.006	265	326	0.41 (1)	746	930
10/14/92	< 0.049		0.676		0.257	300	265.2	0.5 (1)	716	473.3
11/10/92	< 0.04		0.007		0.016	285	275	0.44 (1)	715	638.3
12/2/92	< 0.05		0.005		0.009	301	287	0.49 (1)	875	1830
1/5/93	< 0.03		< 0.002		0.012	303	297	1.03 (1)	686	1950
2/3/93	< 0.03		< 0.002		0.007	300	289	0.43 (1)	728	3110
3/2/93	< 0.03		< 0.002		0.011	302	321	0.68 (1)	754	1560
4/6/93	< 0.04		< 0.001		0.013	297	327	0.92 (1)	782	23.4
5/11/93	< 0.04		< 0.001		0.006	250	227	0.76 (1)	513	73.3
6/8/93	< 0.04		< 0.001		< 0.001	251	172	0.5 (1)	538	316
7/7/93	< 0.04		< 0.002		0.006	265	163	0.42 (1)	503	16.5
8/5/93			< 0.002		0.004	274	185	0.43 (1)	586	33.5
9/14/93	< 0.02		0.05		< 0.01	240	290	0.81 (2)	616	780
10/6/93	< 0.02		< 0.01		< 0.01	302	263	1.01 (2)	666	< 2
11/2/93	< 0.02		< 0.01		< 0.01	296	278	1.01 (2)	710	< 2
12/7/93	< 0.02		< 0.01		< 0.01	282	218	1.26 (2)	602	16
2/8/94	< 0.02		0.02		0.03	312	234	0.73 (2)	642	78
3/8/94						306	249	0.87 (2)	648	2
4/6/94	< 0.02		< 0.01		< 0.01	284	247	1.97 (2)	670	< 2
5/10/94	< 0.02		< 0.01		< 0.01	270	187	0.7 (2)	484	< 2
Summary Statistics:										
LF-2 Maximum	0.05		0.676		0.257	312	335	1.97	1414	3110
LF-2 Minimum	0.001		0.001		0.001	240	163	0.4	484	2
LF-2 Average	0.027		0.036		0.022	282	263	0.7	702	761.2
n	23		24		24	25	24	25	25	25
≥State GW Criteria?	YES (3)		YES (3)		NO (3)		YES	YES	YES	

(1) Total $NO_3 + NO_2$ - N

(2) Dissolved NO_3-N

(3) Dissolved concentration compared to GW criteria for total metals

Notes: Well inaccessible and not sampled: Jan. 94

NOTES ON TABLES OF SELECTED WQ DATA FOR LF-I, LF-1, AND LF-2 LAMEFOOT MINE

Tables are constructed in Excel 5.0 with appropriate formatting in cells to calculate maxima, minima, averages, and whether parameter equals or exceeds state groundwater criteria. When entering new data, care will need to be taken that cells for new data are formatted to calculate in updated statistics. Graphs should be updated to include new data in the date and concentration ranges.

Abbreviations include the following:

n = number of observations
SC = specific conductivity
T = total recoverable (unfiltered)
D = dissolved (filtered)
As = arsenic
Cu = copper
Fe = iron
Pb = lead
Mn = manganese
Zn = zinc
Alk. = alkalinity (as $CaCO_3$)
NO_3 = nitrate (as N)
TDS = total dissolved solids
TSS = total suspended solids

Graphs of selected indicator parameters (field pH and specific conductivity, total alkalinity, iron, manganese, zinc, sulfate, nitrate, and TDS) have been constructed and linked to the Excel spreadsheets. Parameters have been chosen based on key indicators of potential acid rock drainage and parameters on the short list to be analyzed most frequently in future monitoring. Graphs were constructed for an indicator parameter when there were more than two observations for that parameter at that site.

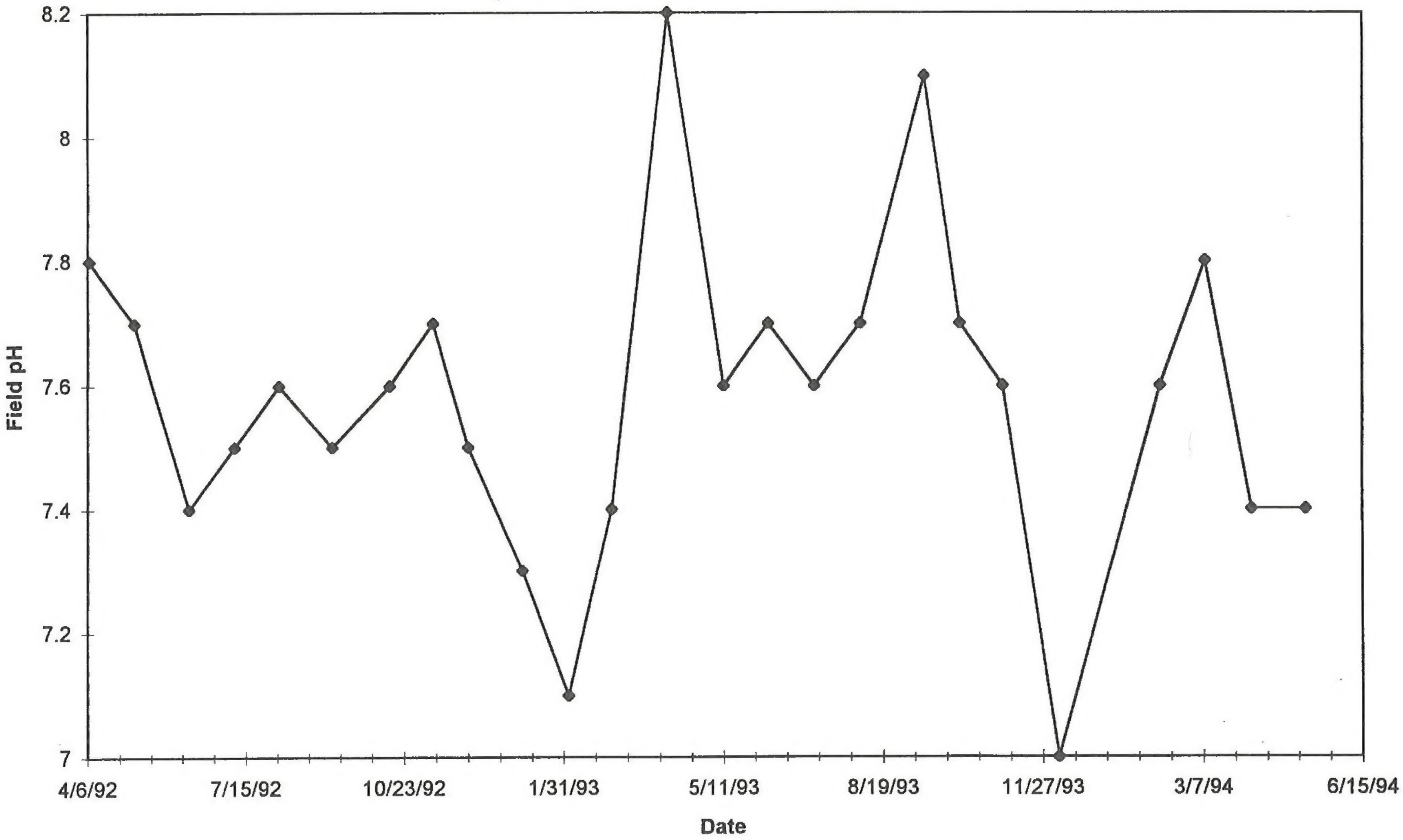
Where qualified data (such as concentrations below the detection limit [i.e., < 0.05 mg/L]) exist, the parameter has been assumed to be present at the detection limit for purposes of calculating maxima, minima, and averages. The "YES/NO" in the last row indicates that the maximum value for that parameter equals or exceeds the state groundwater criterion. State groundwater criteria are stated in terms of total metals concentrations. However, it is assumed that if a dissolved (filtered) sample equals or exceeds the criteria, a corresponding total sample also would equal or exceed the criteria, since total concentrations generally exceed dissolved concentrations when measured on aliquots of the same sample. Columns for chemical parameters are divided into a column preceding the number (for < or other appropriate symbols), the column for the chemical result to be used in calculations, and a column following the number (for footnotes).

Selected data results appeared to be lab errors, in that results were clearly anomalous and appeared unreasonable. These results were not entered in the database tables, including the following: The conductance result for the 6/8/93 sample for LF-I (the lab reported 0.2 umhos/cm, anomalously low); the sulfate result for the 8/5/92 sample for LF-2 (the lab reported 0.3 mg/L, anomalously low); and the lead result for the 8/5/93 sample for LF-2 (the lab reported an anomalously high value which repeated the result for dissolved magnesium). Anomalously high results were reported for dissolved iron for the 10/14/92 samples from LF-1 and LF-2 (22.8 and 48.4 mg/L, respectively, for LF-1 and LF-2). Although these dissolved iron data are suspect, it is not clear without more information that they can be attributed to lab error. Thus, these dissolved iron results have been noted as anomalous but retained in the database.

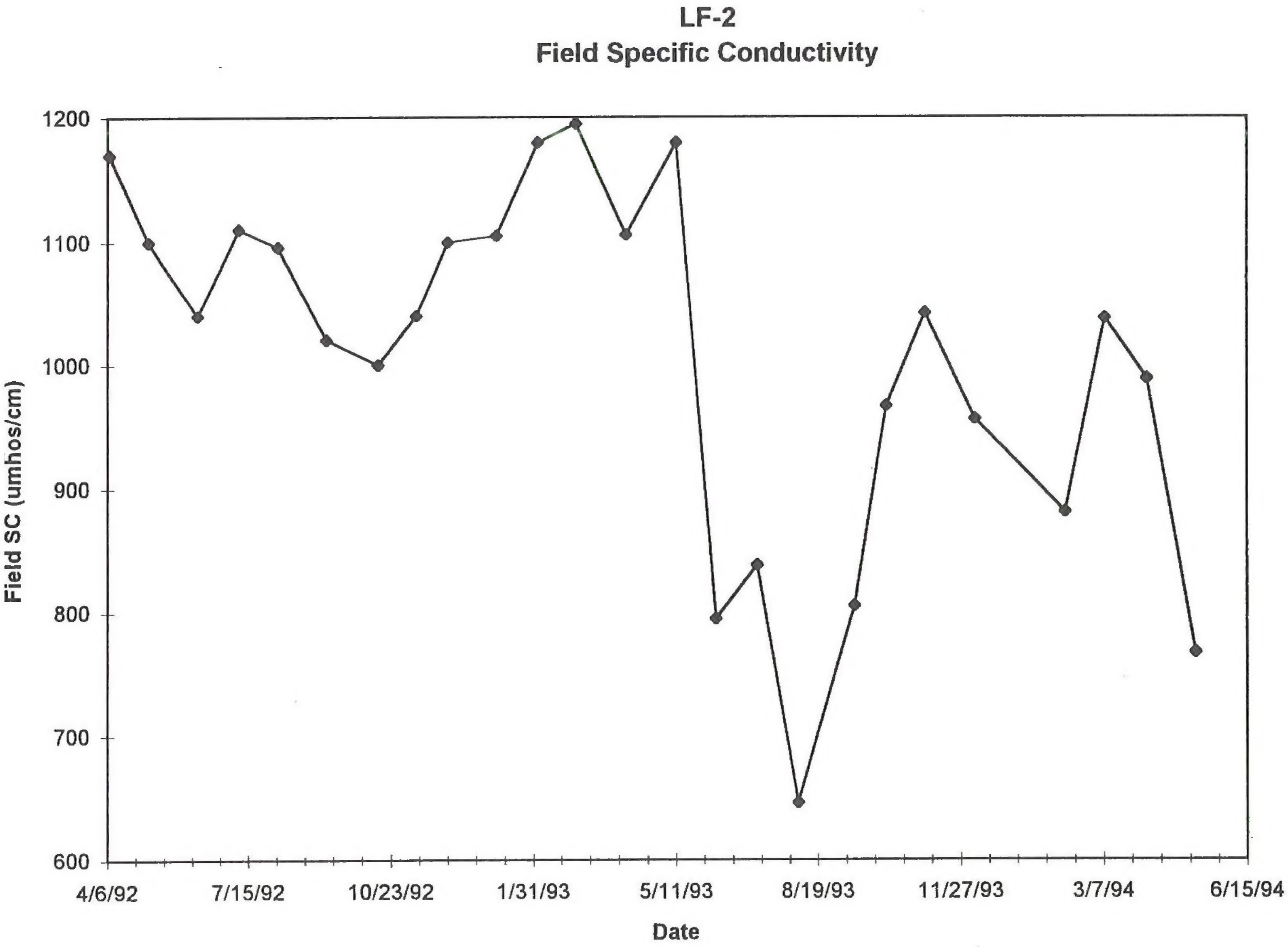
Cyanide is not included as an indicator parameter and historically has not been detected in the infiltration pond LF-I and wells LF-1 and LF-2, except for results reported from monthly sampling of LF-1 and LF-2 in September and October 1993. Results from those two months, reported during a changeover from SVL to ACZ labs, indicated total cyanide ranging from 0.008 to 0.003 mg/L. These values are well below the previous laboratory reporting limits of 0.01 mg/L for WAD (weak acid dissociable) cyanide, which was not detected by SVL labs. According to Echo Bay Minerals, cyanide has not been used in this area and they are not required to monitor for cyanide in LF-I, LF-1, or LF-2. Cyanide detections reported in September and October 1993 may represent false-positives near the detection limit or laboratory blank contamination.

The site LF-I represents sampling from the infiltration and evaporation pond, which receives discharge from the mine adit as well as from the mine shop and wash bay areas.

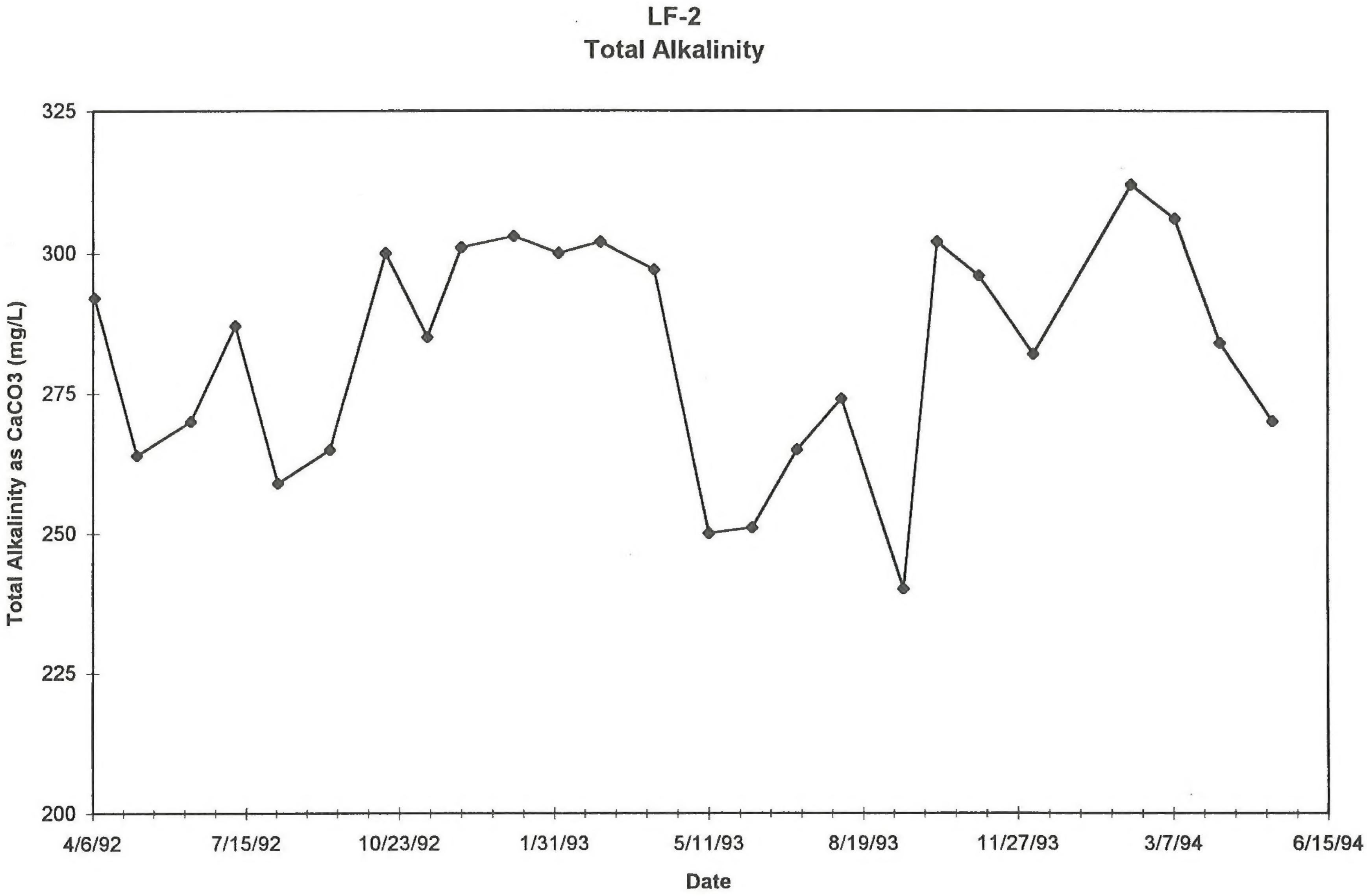
LF-2
Field pH



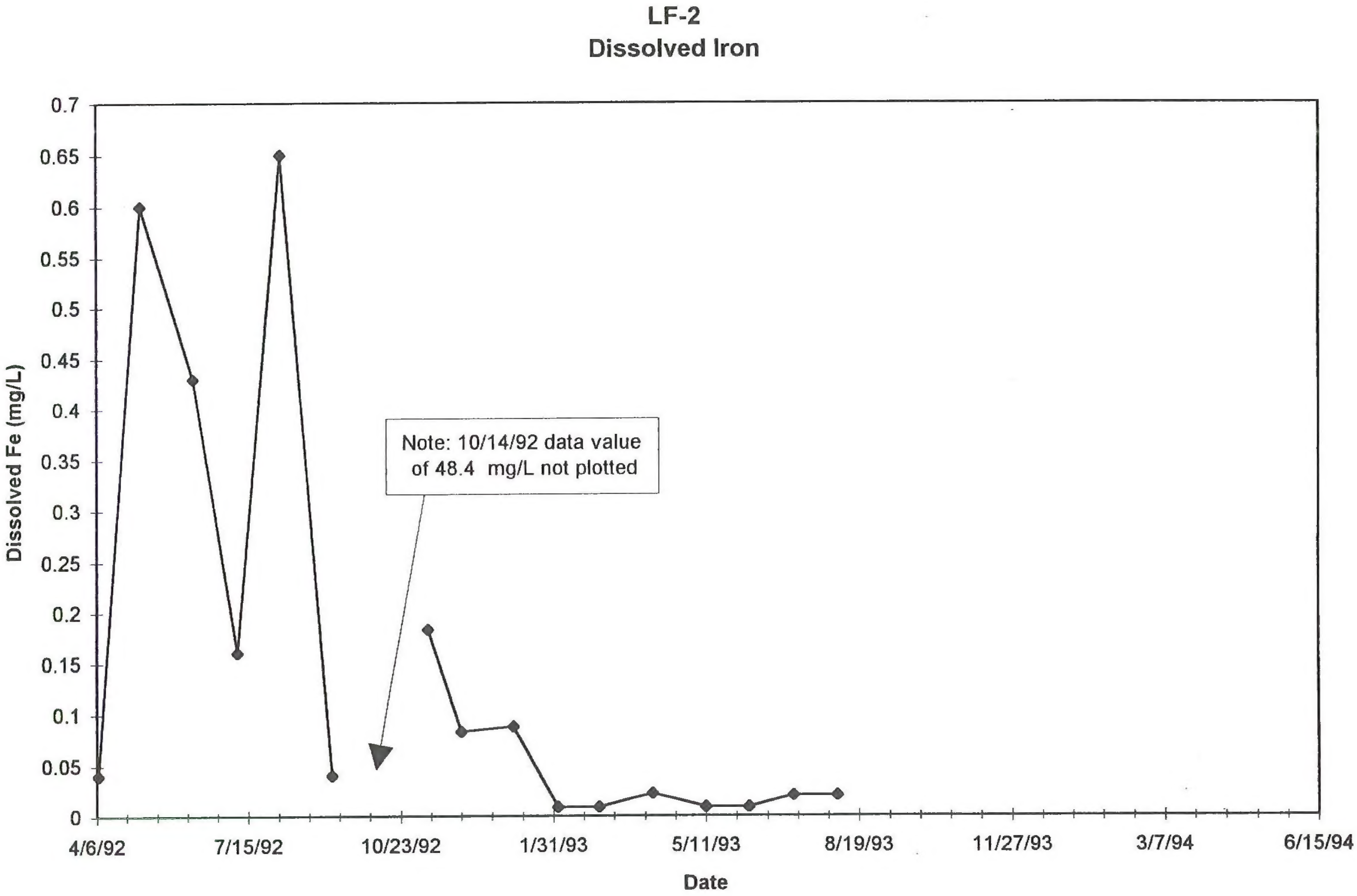
LF2pH.xls


LF-2
Field Specific Conductivity
Field SC (umhos/cm)
1200
1100
1000
900
800
700
600
4/6/92
7/15/92
10/23/92
1/31/93
5/11/93
8/19/93
11/27/93
3/7/94
6/15/94
Date

LF2SC.xls



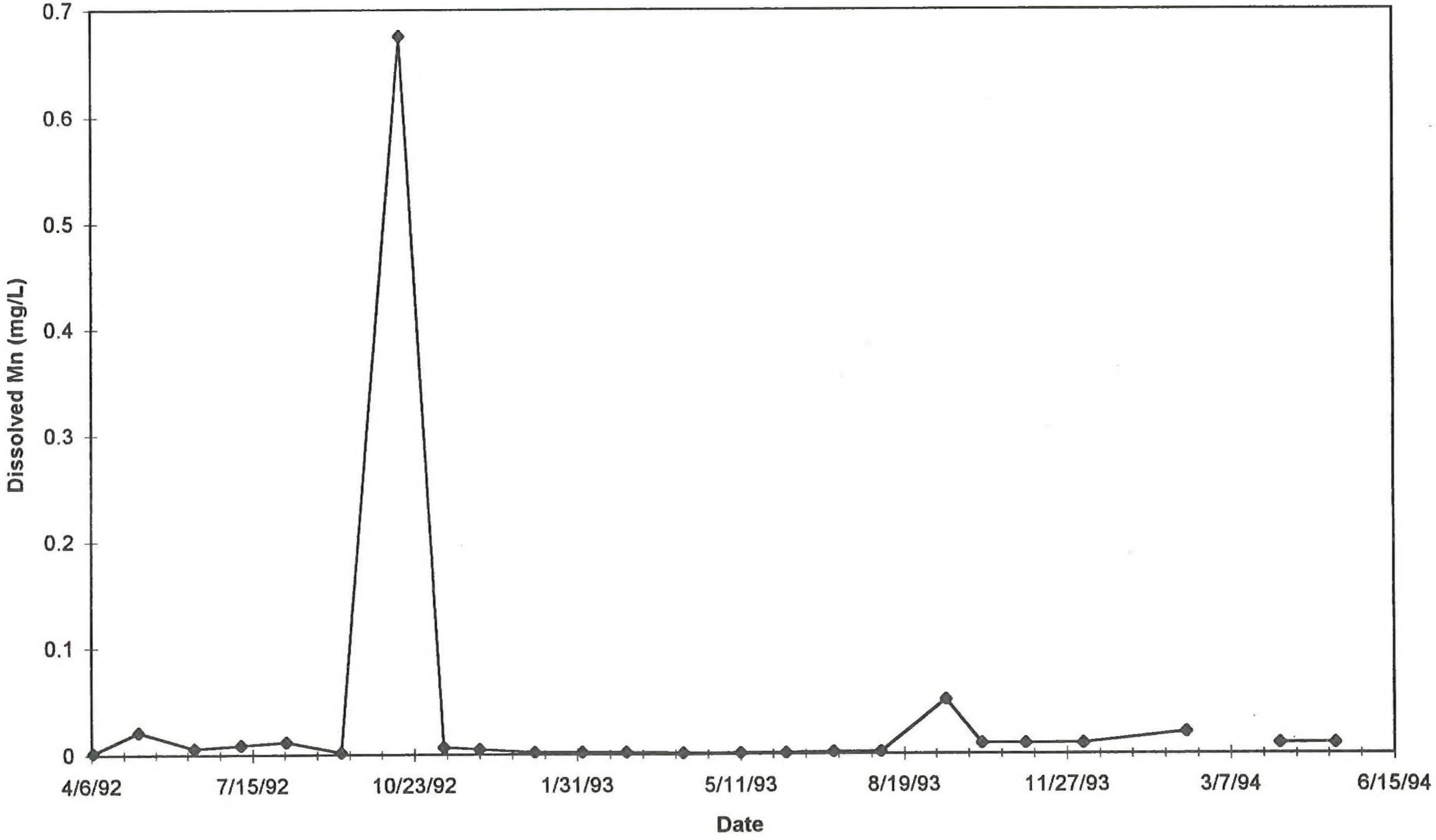
LF2TotAlk.xls



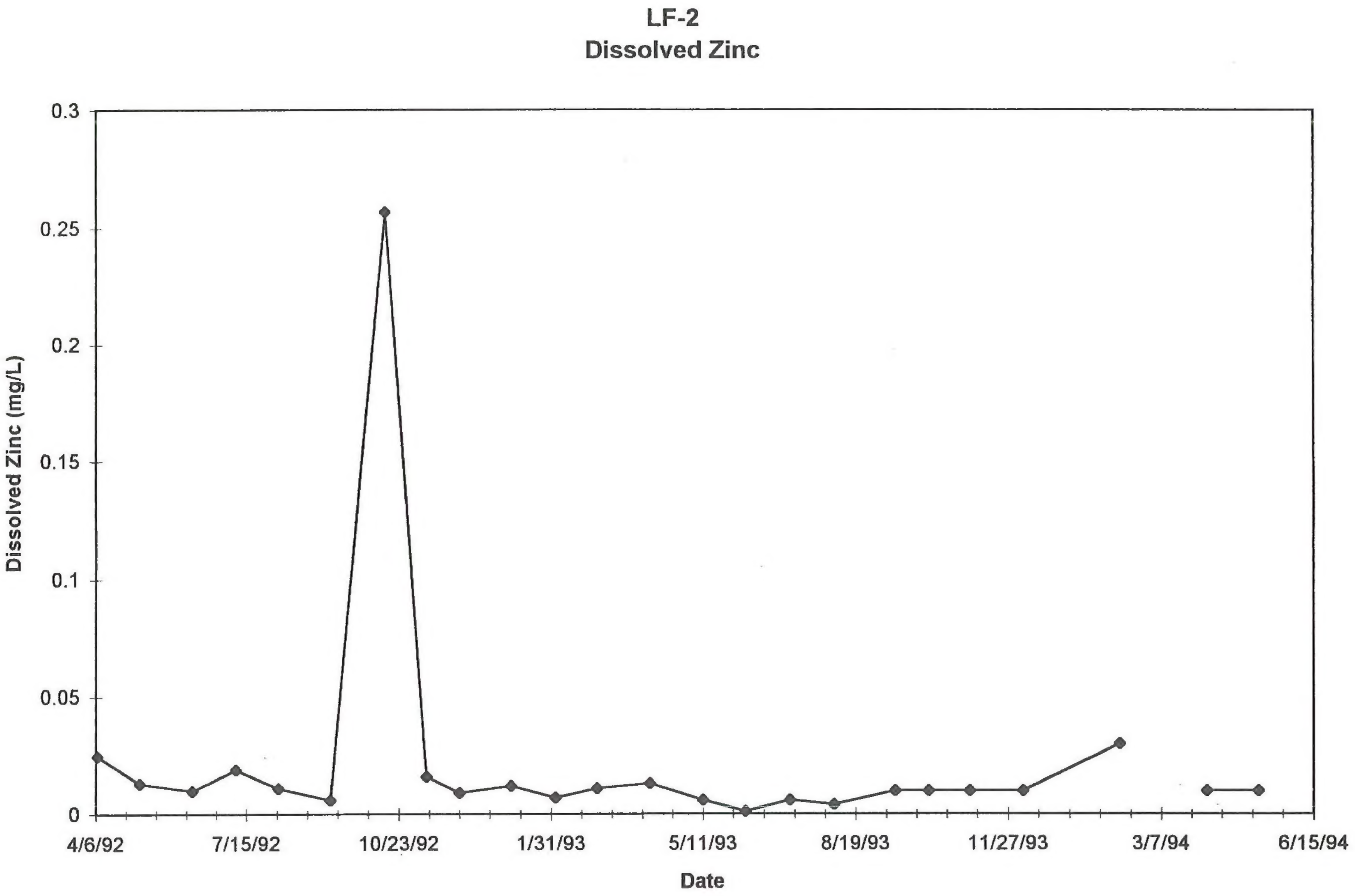
Note: 10/14/92 data value of 48.4 mg/L not plotted

LF2DisFe.xls

LF-2
Dissolved Manganese

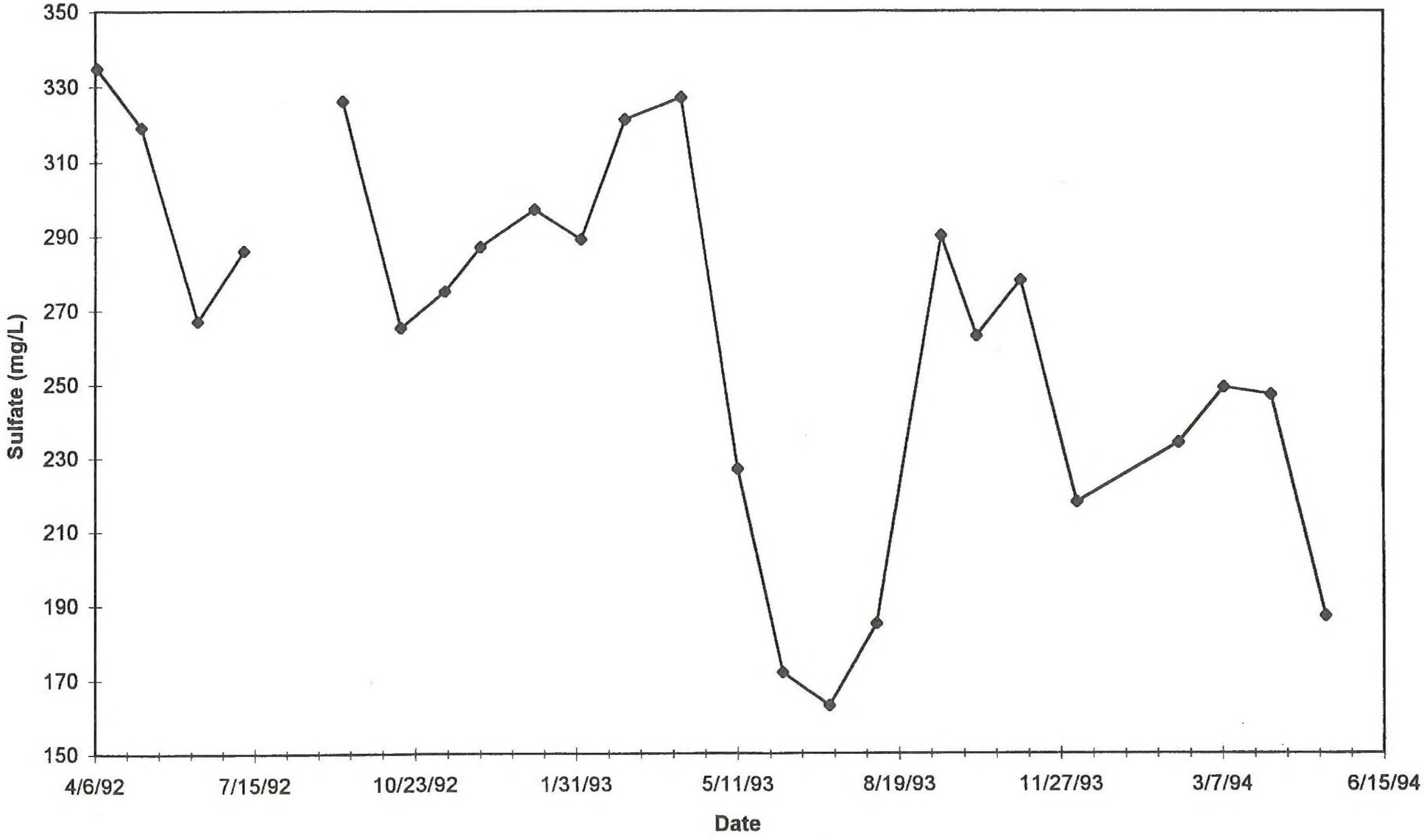


LF2DissMn.xls



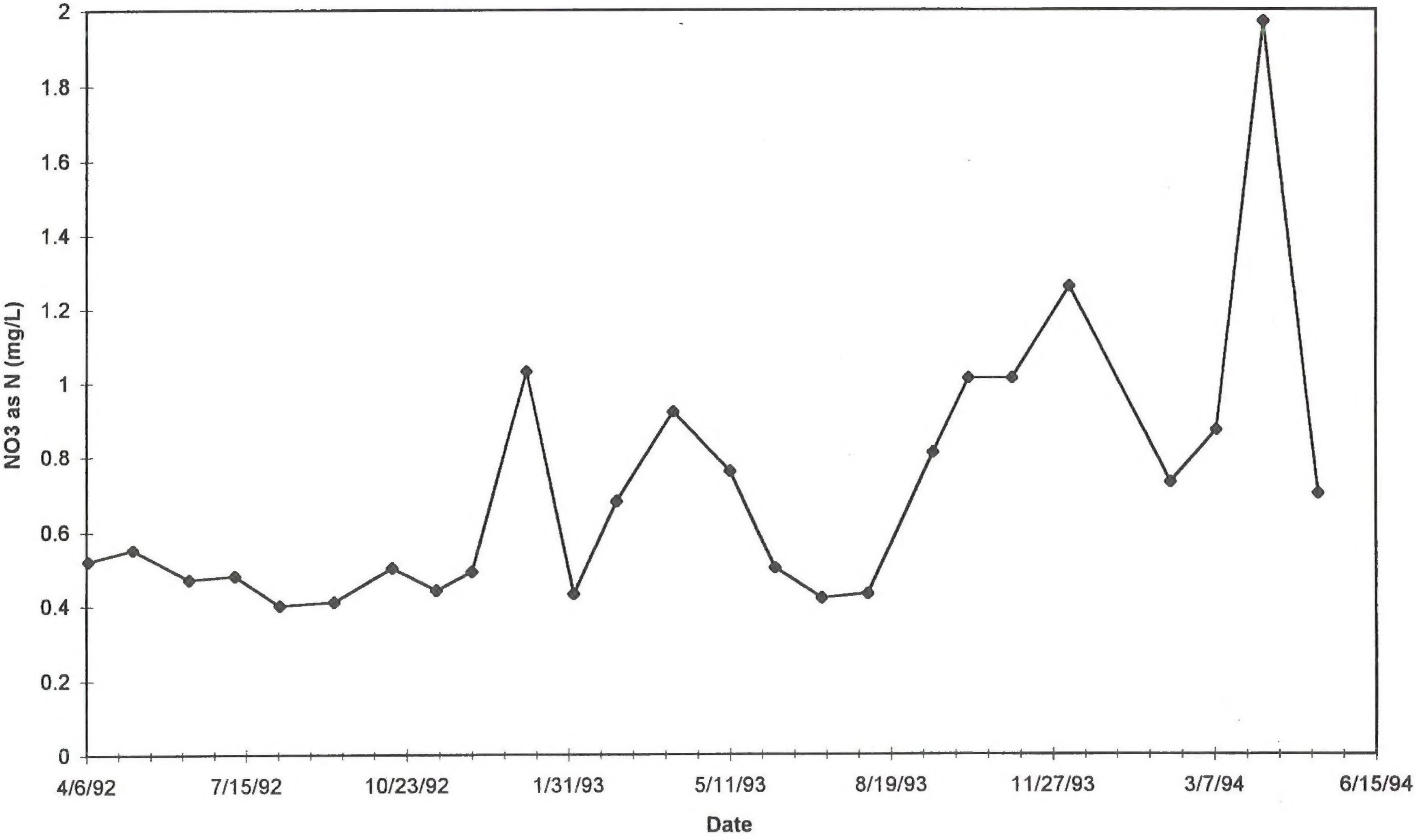
LF2DissZn.xls

LF-2
Sulfate



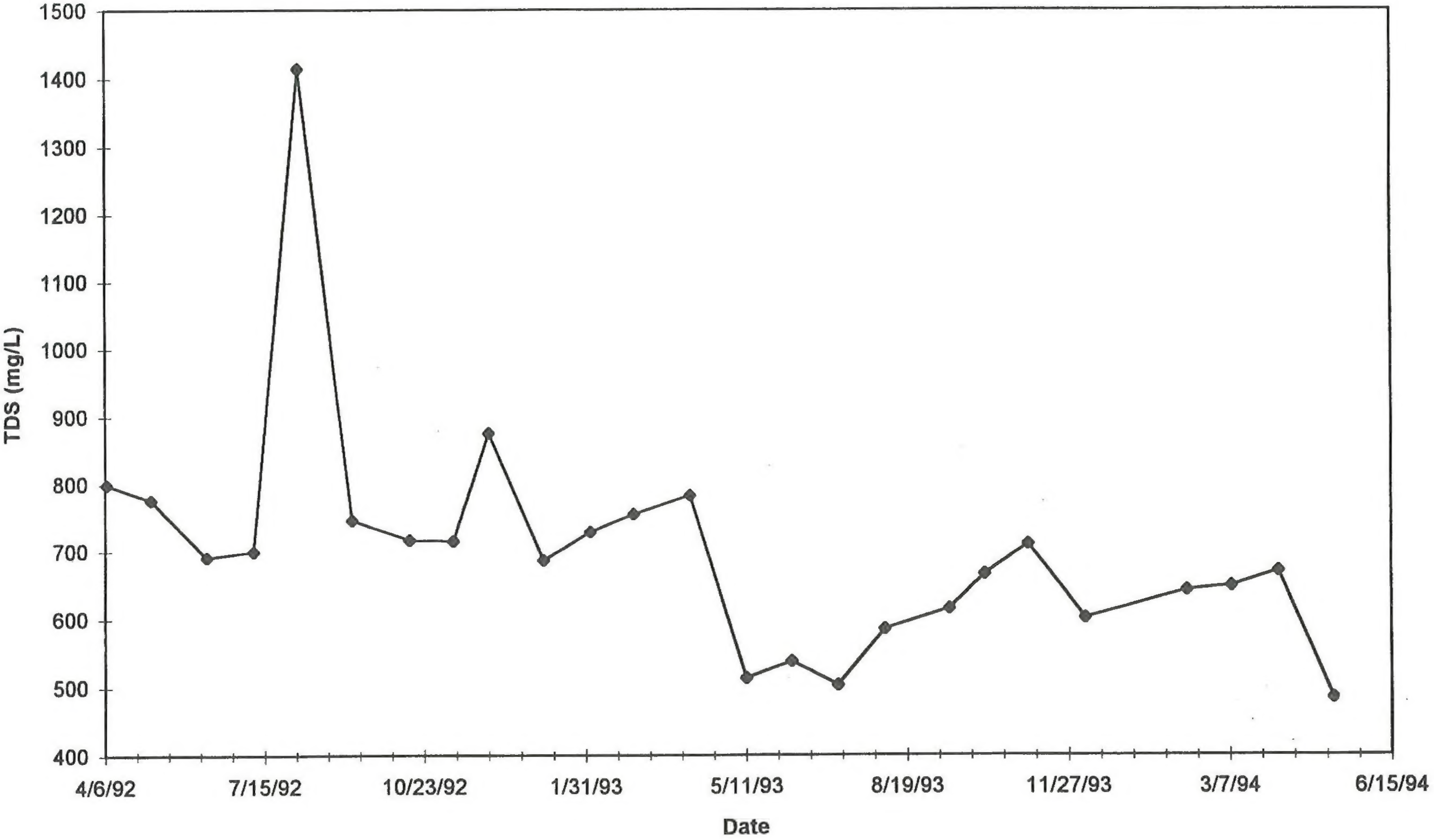
LF2SO4.xls

LF-2
Nitrate as Nitrogen



LF2NO3.xls

LF-2
Total Dissolved Solids



LF2TDS.xls

APPENDIX C-3
INTERPRETATION OF WATER QUALITY

APPENDIX C-3
ADDITIONAL INTERPRETATION OF WATER QUALITY

Background Water Quality

Only two wells exist for which long-term water quality data are available, LF-1 and LF-2. A summary letter with graphs and tables of these data were submitted to BLM on July 13, 1994. That summary letter is included in Appendix C-2. These data are summarized in Table 2.0 and may be considered as one measure of background water quality. Both wells are upgradient of any known sources of contamination.

Additional water quality samples were collected during late September, 1994, many at newly-drilled wells. These data were sent to BLM between October 10 and 13, 1994 and detailed interpretations are presented in a supplemental Water Quality Technical document to be prepared.

Field data for these September, 1994 data are shown on Table 1.0. These September, 1994 data were used to construct Table 3.0 which presents another approach to determining background water quality. This table was compiled using historical and new data from wells LF-1 and LF-2 (as in Table 2.0), and new data from LF-4, LF-5, LF-8 the Heckly and Corl wells, SP-10 (State Park well), MSW (mine supply well), LFC-432 (mine seep), and springs 2605 and 3035. Several of the September, 1994 samples were not included in Table B for the following reasons:

- Samples from LF-3 and LF-7 had elevated field pH's, suggesting possible remnant contamination from well construction by cement and/or bentonite. These wells have been developed, but the very low water yields have prevented effective cleaning of the wells. Elevated pH's would cause changes in all the redox-sensitive constituents, i.e. many metals, alkalinity, TDS, and S.C.

- LF-9, a shallow (8 feet deep) drive-point well, also had elevated field and lab pH's, 10.3 and 10.4 respectively, but the reason is undetermined at this time. LF-9 did not contain elevated NO_3, which measured 0.09 mg/l. Elevated pHs (between 9 and 12) have been reported in Hem, 1985, for river and lake waters due to release of CO_2 by organisms during respiration.

- LF-6 had a turbid sample that showed apparent irregularities, in the fluoride, TSS, sodium, and total aluminum, iron, manganese, and zinc. The specific reason for the chemical irregularities of this low-yield well are undetermined at this time.

Two wells with elevated nitrate concentrations (i.e., LF-8 and SP-10), were included in background Table 3.0 because, it appears that the other constituent concentrations (besides nitrogen forms) are representative of background. The elevated nitrates have been flagged. Several possible explanations for the elevated nitrate exists, from both natural and contaminated sources: the mine portal and waste rock discharges, septic tanks and leach fields, agricultural products and organic-rich sediments. It is known that Curlew Lake has suffered from a eutrophication problem prior to the development of the Lamefoot Mine. Given the present data, it is not possible to determine a truly reliable estimate of background for nitrate.

Since several of the wells yield very little water, the samples are often sediment-laden. When acid preservative is added to such turbid samples in the field, constituents originally in particulate form are dissolved. For this reason, many of the total (unfiltered) concentrations for both metals and major ions are not considered representative of background.

Water Quality Results

Data form background wells LF-1 and 2 (see Appendix C-2) show no obvious historical trends in water quality. Changes probably reflect normal seasonal, sampling and analytical variability. Summary tables and graphs of the mine infiltration pond data (LF-I) are also included in Appendix C-2. These data show that the mine water has contained elevated nitrate concentrations, but that such concentrations have declined since mining ceased at the end of March, 1994. Some of the decline is probably also due to dilution from spring runoff, and increased effort by Echo Bays at improving explosive handling practices.

The September, 1994 data show nitrate concentrations exceeding the Washington groundwater criteria at the State Park well (13.6 mg/l), LF-7 (18.7 mg/l), and LF-8 (30.4 mg/l). Since these wells are west of the mine site boundary and near the lake, several explanations for the elevated nitrate are possible. It is possible, though not confirmed, that exploration blasting activities and mine discharge may have contributed to these elevated nitrate concentrations. It is likely that much of the shallow groundwater around the margins of the Lake has elevated nitrate levels due to drainage from septic tanks and leach fields, contamination by breakdown products from organic-rich lake sediments, nitrogen-rich fertilizers and other agricultural chemicals. As noted previously, the exact cause cannot be determined with the present data set.

If private wells were to be deemed contaminated as a result of mine contamination, activities such as those mentioned in the Limited Mining Alternative document (BLM, October 6, 1994), item 13 would be instituted. That is, "Any detection of constituents at concentrations greater than (a) trigger levels or (b) more stringent State or Federal standards, would be reported within 24 hours to BLM and to the appropriate State agency. If either of these occur, BLM will require expanded monitoring measures as stated above, plus remediation measures for water quality degradation that threatens to impact beneficial use or natural resources. Remediation could include interception wells, slurry cut-off walls, replacement of water supplies for domestic use, water treatment, and replacement of wetland water supplies."

Elevated dissolved antimony concentrations reported in the September 1994 data result from impurities contained within the filter papers used. No comparable concentrations are seen in the unfiltered results, and the lab reports that they have verified this source of contamination from several other studies.

As mentioned, waters from the mine workings (LF-I) have contained elevated concentrations of nitrate in the past, but concentrations have declined since the end of March 1994. ANFO was discontinued. Figure 1.0 shows underground nitrate concentrations and their obvious decline. The September 1994 nitrate concentration at LF-I was 4.05 mg/l, and at LFC-432 (the underground seep), 0.09 mg/l. LF-I has had average concentrations of the following constituents (4/6/93 to 5/10/94): field pH 8.0, total arsenic 0.04 mg/l, total copper 0.02 mg/l, total iron 3.17 mg/l, total lead 0.03 mg/l, total manganese 0.112 mg/l, total zinc 0.064 mg/l, total alkalinity 208 mg/l, sulfate 545 mg/l, TDS 978 mg/l, nitrate 51.7 mg/l. As mentioned previously, nitrate concentrations have been reduced significantly since April, 1994 when these data were compiled. The LF-I data are presented in Appendix C-2.

During periods of non-discharge from the mine into the infiltration pond, samples for nitrate determination have been collected weekly. Starting in September 1994, weekly "complete" water quality samples are also being collected from the mine sump.

Some of the constituent concentrations in the infiltration pond (LF-I) waters have exceeded Washington Groundwater criteria in the past (i.e. total arsenic, total iron, total manganese, sulfate, TDS and nitrate). Metals such as iron, cadmium, manganese, zinc, lead, arsenic, and copper would be greatly attenuated if released into the groundwaters west of the mine workings. Such attenuation would be partly caused by a reduction in solubility as a result of dilution and neutralization by the high alkalinity local groundwaters. In addition, attenuation would occur because of adsorption of metal cations on the surfaces of clays, iron oxyhydroxides and other charged surfaces, and by ion exchange. Manganese and zinc may be somewhat more mobile than most of the other metals in this environment. Anions such as sulfate and nitrate are much less attenuated by adsorption, ion exchange or oxidation-reduction reactions than metals. Their concentrations would decline more via sample dilution and to some extent chemical reaction. However, nitrate and sulfate concentrations would be reduced much less than that of the metals at the permit boundary.

Attempts at using transport and chemical equilibrium modeling in such geologic settings yield very imprecise results largely because of the great uncertainty involved in the attenuation characteristics and the fractured nature of the aquifer.

TABLE 1.0
FIELD SAMPLING DATA
LAMEFOOT MINE

Sampling Location	Date	pH	Specific Conductance (μmhos/cm)	Temperature (°C)	Turbidity (NTU)	Static Water Level (ft MSL)	Flow Rate (gpm)
LF-1 (well)	9/27/94	7.7	711	11	0.6	2533.68	NA
LF-2 (well)	9/27/94	7.6	750	7	>200	2639.81	NA
LF-3 (well)	9/26/94	9.8	861	13	>200	2609.16[1]	NA
LF-4 (well)	9/27/94	7.6	1020	12	26	2646.84	NA
LF-5 (well)	9/27/94	7.6	750	21	>200	2505.40[2]	NA
LF-6 (well)	9/28/94	8.5	729	10	56	2475.46[3]	NA
LF-7 (well)	9/28/94	10.0	428	10	78	2465.82	NA
LF-8 (well)	9/28/94	6.9	900	11	1	2461.50[4]	NA
LF-9 (well)	9/28/94	10.3	105	15	>200	2462.0	NA
State Park Well	9/28/94	8.0	822	12	6	NM	NA
CORL Well	9/28/94	7.9	598	11	12	2493[5]	NA
HECKLEY Well	9/24/94	7.7	532	15	6	NM	NA
Mine Supply Well	9/27/94	7.3	853	12	1	2506.61	17
Spring 3035′	9/27/94	7.6	625	11	0.3	NA	0.5
Spring 2605′	9/27/94	7.7	736	11	2	NA	4.2
Wetland 2845′	9/27/94	NM	NM	NM	NM	Dry	NA
Wetland 2545′	9/27/94	8.1	400	19	20	2533.14	0
Wetland 2540′	9/27/94	NM	NM	NM	NM	Dry	NA
Wetland 2495′	9/27/94	NM	NM	NM	NM	Dry	NA
Infiltration Pond	9/27/94	8.0	798	20	26	NM	NA
Seep LFC-432	9/28/94	7.1	1032	9	2	NA	2.9
Seep LFC-120	9/28/94	6.9	2010	9	>200	NA	2.9

NM = Not Measured
NA = Not Applicable

[1] Water level not fully recovered after previous well development. Recovered Static Water Level = 2840.2.

[2] Water level not fully recovered after previous well development. Recovered Static Water Level = 2510.9.

[3] Water level not fully recovered after previous well development. Recovered Static Water Level = 2478.5.

[4] Water level not fully recovered after previous well development. Recovered Static Water Level = 2463.7.

TABLE 2.0

BACKGROUND WATER QUALITY USING LF-1 AND LF-2
LAMEFOOT PROJECT VICINITY

Constituent	Background Range	n	Average	Washington Groundwater Quality Criteria
Indicator Parameters				
Total Dissolved Solids (TDS) (mg/l)	455 - 1414	48	622.5	500
Arsenic, Dissolved (mg/l)	0.002 - 0.108	48	0.028	
Arsenic, Total (mg/l)	----	--	----	0.05 (μg/l)
Manganese Dissolved (mg/l)	0.001 - 0.676	47	0.034	
Manganese, Total (mg/l)	----	--	----	0.05
Nitrate (mg/l)	0.4 - 1.99	48	0.8	10
Iron, Dissolved (mg/l)	0.009 - 48.4	32	2.34	
Iron, Total (mg/l)	----	--	----	0.3
Sulfate (mg/l)	152 - 335	47	228	250
pH Lab (units)	7.19 - 8.2	48	7.75	6.5-8.5
Secondary Parameters				
Lead, Dissolved (mg/l)	0.001 - 0.1	46	0.032	
Lead, Total (mg/l)	----	--	----	0.05
Zinc, Dissolved (mg/l)	0.001 - 0.257	47	0.020	
Zinc, Total (mg/l)	----	--	----	5

Note: Washington Ground Water Quality Criteria refer to total concentrations.

TABLE 3.0

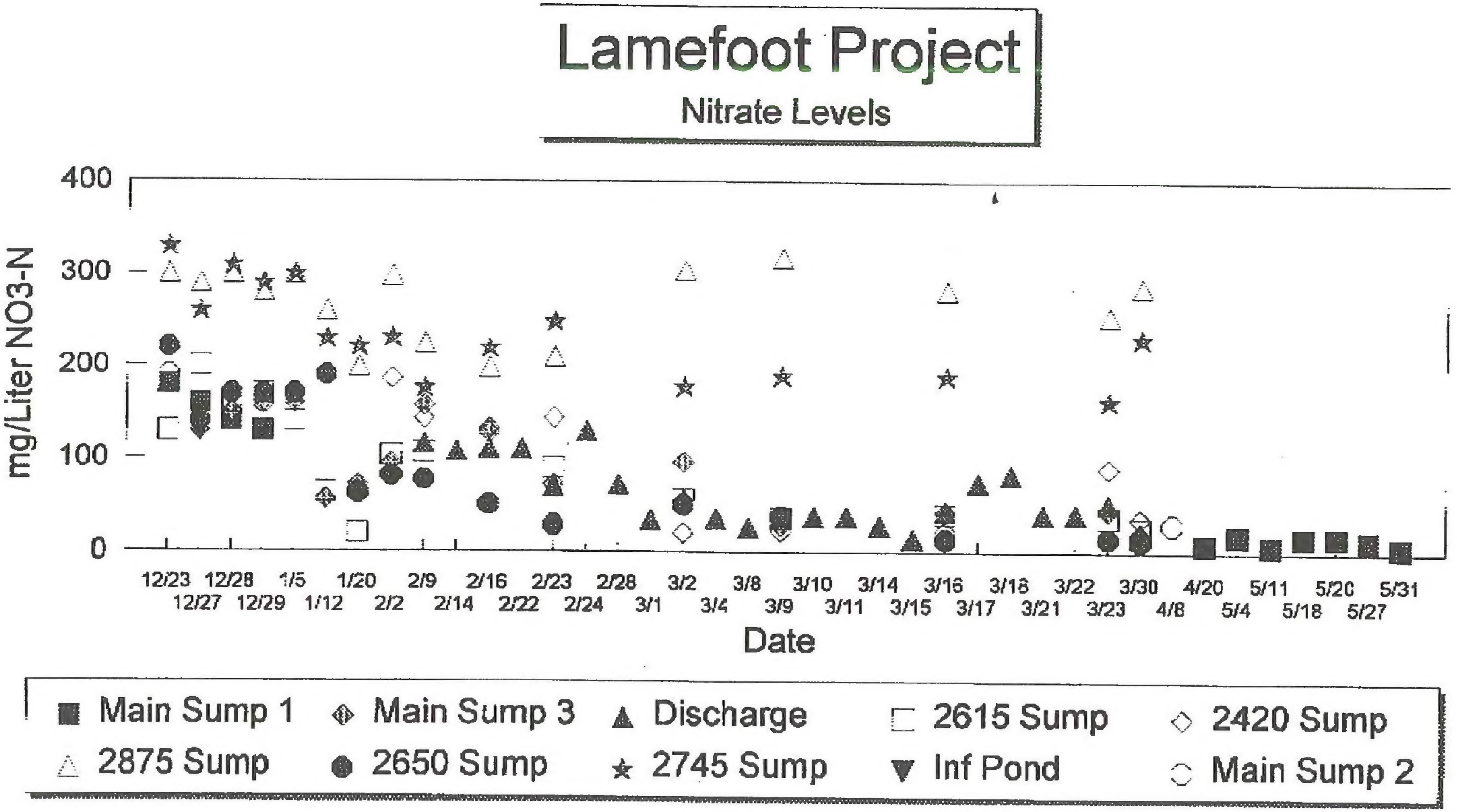
PRELIMINARY BACKGROUND WATER QUALITY LAMEFOOT PROJECT VICINITY

Constituent	Background Range (mg/l)			Washington Groundwater Quality Criteria (mg/l)
	Minimum	Maximum		
Indicator Parameters				
Total Dissolved Solids (TDS)	340	1414		500
Arsenic, Dissolved	0.001	0.108		
Arsenic, Total	0.002	0.04		0.05 (ug/l)
Manganese, Dissolved	0.001	0.676		
Manganese, Total	< 0.01	0.36		0.05
Nitrate	0.03	13.6	(30.4)*	10
Iron, Dissolved	0.009	48.4		
Iron, Total	0.03	12.2		0.30
Sulfate	43	335		250
pH, Field (units)	6.9	8		6.5-8.5
pH, Lab (units)	6.9	8.2		
Secondary Parameters				
Lead, Dissolved	< 0.001	0.10		
Lead, Total	< 0.001	0.155		0.05
Zinc, Dissolved	0.001	1.73		
Zinc, Total	< 0.01	67.0		5.0

* Elevated concentration at LF-8 that may not represent background.

Notes:
Units are mg/l except where noted.
Ranges are based on water quality data from the following wells: LF-1, LF-2, LF-4, LF-5, LF-8, Corl well, Heckley well, Mine Supply well, SP-10 (State Park well), LFC-432 (underground Mine Seep), Springs 2605 and 3035. Samples were collected 9/26/94 - 9/28/94. Historical data from wells LF-1 and LF-2 were also used in compiling the table. Some dissolved concentrations exceeded totals when historical data from LF-1 and LF-2 were added to the data set.

FIGURE 1.0


Lamefoot Project
Nitrate Levels
400
300
200
100
0
mg/Liter NO3-N
12/23
12/27
12/28
12/29
1/5
1/12
1/20
2/2
2/9
2/14
2/16
2/22
2/23
2/24
2/28
3/1
3/2
3/4
3/8
3/9
3/10
3/11
3/14
3/15
3/16
3/17
3/18
3/21
3/22
3/23
3/30
4/8
4/20
5/4
5/11
5/18
5/20
5/27
5/31
Date
■ Main Sump 1
◈ Main Sump 3
▲ Discharge
□ 2615 Sump
◇ 2420 Sump
△ 2875 Sump
● 2650 Sump
★ 2745 Sump
▼ Inf Pond
○ Main Sump 2

APPENDIX D
SUBSIDENCE EFFECTS

TABLE D-1

PHYSICAL PROPERTIES UTILIZED IN NUMERICAL MODELING

Estimation of Unconfined Rock Mass Compression Strength

Unconfined Specimen Compression Strength (Addendum 2, p 2),
Limestone **Pls** - 15,000 psi, and Clastics **Pcl** - 21,600 psi

Strength Reduction for Size Effect

Widely jointed Limestone, Strength reduction divisor ≈ 5.5
(Pratt, et al, 1972)

∴ Limestone mass strength ≈ 15,000/5.5 ≈ 2750 psi

Closely jointed Clastics, Strength reduction divisor ≈ 7.5
(Bieniawski, 1968)

∴ Clastic mass strength ≈ 21,600/7.5 ≈ 2900 psi

Estimation of Rock Mass Deformation Modulus

Barton, et al (1974) "Q" Classification for Lamefoot rocks
Limestone = 53, Clastics = 2 (Roberts & Moss, 1993)

Barton, et al (1983) presented relationship between in situ deformation modulus (E) and "Q", as follows:

Mean $\overline{E} = 25 \log_{10} Q$
Maximum $E_{max} = 40 \log_{10} Q$

∴ Limestone mass $\overline{E} = 25 \log_{10}(53) = 43$ GPa (6.25×10^6 psi)
∴ Limestone mass $E_{max} = 40 \log_{10}(53) = 69$ GPa (10.0×10^6 psi)
∴ Clastics mass $\overline{E} = 25 \log_{10}(2) = 7.5$ GPa (1.09×10^6 psi)
∴ Clastics mass $E_{max} = 40 \log_{10}(2) = 12$ GPa (1.75×10^6 psi)

Bieniawski (1983) presented a relationship between the mean in situ deformation modulus ($\overline{E}$), "Q" and Rock Mass Rating (RMR), as follows:

$RMR = 9 \ln Q + 44$ and $\overline{E} = 2\ RMR - 100$
∴ Limestone mass $RMR = 9 \ln(53) + 44 = 80$
∴ Clastics mass $RMR = 9 \ln(2) + 44 = 50$

∴ Limestone mass $\overline{E} = 2(80) - 100 = 60$ GPa (8.7×10^6 psi)
∴ Clastics mass $\overline{E} = 2(50) - 100 = 0$ MPa (0.0×10^6 psi) ?

Bieniawski (1983) presented the deformation modulus reduction between laboratory and field determinations for 42 tests. The mean deformation modulus reduction multiplier was 0.457, with a standard deviation of 0.285. Therefore, the recommended deformation moduli (E) for design are, as follows:

Limestone mass $E = 0.457$ (8.7×10^6 psi) $= 4.0 \times 10^6$ psi
Clastics mass $E = 0.457$ (1.75×10^6 psi) $= 0.80 \times 10^6$ psi

TABLE D-2

MAXIMUM POSSIBLE SURFACE SUBSIDENCE (INCHES) ABOVE NEAR-SURFACE STOPES[1]

Section[2]	Stope[2] Number	Open Stopes No Backfill	Low-modulus Backfill	High-modulus Backfill
60-foot stope width				
N26090	2	0.95	0.94	0.83
N26930	3	1.35	1.32	1.13
N27250	4	1.37	1.34	1.15
130-foot stope width				
N26090	2	1.24	1.23	1.15
N26930	3	1.68	1.67	1.52
N27250	4	1.62	1.61	1.42

[1] Conservatively assumed equal to total vein closure and no failure of the surface crown pillar.

[2] Section and stope number from Plan of Operations (Echo Bay 1993), Figures 10A and 10B.

TABLE D-3

MAXIMUM POSSIBLE SURFACE SUBSIDENCE INDUCED STRAINS ABOVE NEAR-SURFACE STOPES[1]

Section[2]	Stope[2] Number	Open Stopes No Backfill	Low-modulus Backfill	High-modulus Backfill
Maximum Tensile Strain ($\upsilon\epsilon$) 60-foot Stope Width				
N26090	2	1030	1020	900
N26930	3	1460	1430	1220
N27250	4	1500	1460	1250
130-foot Stope Width				
N26090	2	1340	1330	1250
N26930	3	1820	1810	1650
N27250	4	1760	1740	1540

Section[2]	Stope[2] Number	Open Stopes No Backfill	Low-modulus Backfill	High-modulus Backfill
Maximum Compressive Strain ($\upsilon\epsilon$) 60-foot Stope Width				
N26090	2	870	860	760
N26930	3	1240	1210	1040
N27250	4	1270	1230	1050
130-foot Stope Width				
N26090	2	1050	1050	980
N26930	3	1430	1420	1290
N27250	4	1380	1370	1210

[1] In $\upsilon\epsilon$ - micro-strain, millionths inch per inch.

[2] Section and stope number from Plan of Operations (Echo Bay 1993), Figures 10A and 10B.

TABLE D-4

CROWN PILLAR WIDTH AND THICKNESSES FOR UPPER STOPES

Stope	Section	Crown Pillar		Comments
		Width (ft)	Thickness (ft)	
2	26000N	26	83	Closest to surface
	26100N	37	99	
	26200N	44	114	Widest stope section
	26300N	37	113	
	26400N	40	113	
3	26500N	65	64	Widest stope section
	26600N	23	54	
	26700N	26	50	
	26800N	16	56	
	26900N	16	50	Closest to surface
	27000N	16	50	Closest to surface
Pillar	27100N			
4	27200N	16	42	Closest to surface
	27300N	55	100	
	27400N	54	104	
	27500N	64	150	Widest stope section

TABLE D-5

ROCK STRENGTH TEST RESULTS

Rock Type & Number	Compressive Strength (psi)	Tensile Strength (psi)	Rock Type & Number	Compressive Strength (psi)	Tensile Strength (psi)
Limestone			Clastic		
1	14406	1405	4	19197	2371
2	15457	1216	5	15230	974
7	20811	921	6	13557	1840
11	14668	2402	9	24183	2638
12	16372	1367	10	13198	1689
13	22323	1282	15	23919	1513
16	16440	712	20	20871	1072
18	10785	1536	21	30446	1721
23	16867	830	22	23299	942
24	11400	(1)	25	26319	1381
27	19156	688	26	12248	(2)
29	14735	(2)	28	27053	2206
37	13698	1115	30	28003	1552
38	7847	620	31	(2)	2167
40	11537	752	39	28286	1713
42	13546	1747	41	17983	1747
			44	(2)	1267
Mean	15003	1185	Mean	21586	1675
Std. Dev.	3746	495	Std. Dev.	6057	494
Coef. Var.	25%	42%	Coef. Var.	28%	30%

Rock Type & Number	Compressive Strength (psi)	Tensile Strength (psi)	Rock Type & Number	Compressive Strength (psi)	Tensile Strength (psi)
Massive Magnetite			Intrusives		
			TBR Dike		
3	35959	2313	32	20128	1461
8	16312	1888	35	18727	1989
14	20919	645	36	26078	1898
33	47627	1763	THR Dike		
34	27886	(2)	17	19618	1674
			43	14570	(2)
			TI Dike		
			19	12081	749
Mean	29741	1652	Mean	18534	1554
Std. Dev.	12452	712	Std. Dev.	4858	495
Coef. Var.	42%	43%	Coef. Var.	26%	32%

(1) - Bad Test; (2) - No sample

TABLE D-6

CROWN PILLAR WIDTHS AND THICKNESSES FOR UPPER STOPES

		Crown Pillar		
Ore Zone	Section	Width (ft)	Thickness (ft)	Maximum Allowable Void Height to Eliminate Any Potential Chimney to Ground Surface (ft)
2	26000N	26	83	22.8
	26100N	37	99	27.2
	26200N	44	114	31.4
	26300N	37	113	31.1
	26400N	40	113	31.1
3	26500N	65	64	17.6
	26600N	23	54	14.9
	26700N	26	50	13.8
	26800N	16	56	15.4
	26900N	16	50	13.8
	27000N	16	50	13.8
Pillar	27100N			
4	27200N	16	42	11.6
	27300N	55	100	27.5
	27400N	54	104	28.6
	27500N	64	150	41.3

TABLE D-7

MAXIMUM POSSIBLE, LONG TERM CHIMNEY COLLAPSE DEVELOPMENT WITH RESPECT TO UNFILLED VOID HEIGHT IN STOPE

(Calculation uses 55 percent swell factor measured at Lamefoot site, method presented by Piggott & Eynon, 1977 and wedge type collapse geometry.)

Void Height (ft)	Maximum Possible Wedge-Shaped Collapse Height (ft)	Remarks
0	0.0	Complete stope backfill
3	10.9	Maximum backfill height w/LHD
6	21.8	Minimum personnel working height
10	36.4	Optimum personnel working height
18	65.5	Minimum truck dumping height

TABLE D-8

MAXIMUM POSSIBLE SURFACE SUBSIDENCE (INCHES) ABOVE NEAR-SURFACE STOPES, CONSERVATIVELY ASSUMED EQUAL TO TOTAL VEIN CLOSURE, WITH MAXIMUM ALLOWABLE UNFILLED VOID HEIGHT

Ore Zone	Maximum Height Section	Maximum Stope Height (ft)	Open Stopes No Backfill	Uncemented Backfill	Cemented Backfill
			Uniform 60-ft wide stope width		
2	N26090	450	0.95	0.94	0.83
3	N26930	620	1.35	1.32	1.13
4	N27250	450	1.37	1.34	1.15
			Uniform 130-ft wide stope width		
2	N26090	450	1.24	1.23	1.15
3	N26930	620	1.68	1.67	1.52
4	N27250	450	1.62	1.61	1.42

TABLE D-9

MAXIMUM POSSIBLE SURFACE SUBSIDENCE (INCHES) ABOVE NEAR-SURFACE STOPES, CONSERVATIVELY ASSUMED EQUAL TO TOTAL VEIN CLOSURE, WITH COMPLETE BACKFILLING TO THE STOPE BACK

Ore Zone	Maximum Height Section	Maximum Stope Height (ft)	Open Stopes No Backfill	Uncemented Backfill	Cemented Backfill
			Uniform 60-ft wide stope width		
2	N26090	450	0.95	0.94	0.82
3	N26930	620	1.35	1.31	1.12
4	N27250	450	1.37	1.34	1.14
			Uniform 130-ft wide stope width		
2	N26090	450	1.24	1.23	1.14
3	N26930	620	1.68	1.67	1.51
4	N27250	450	1.62	1.61	1.41

Echo Bay Mineralls, Inc. Plane of Vein Normal Stress, Strain Softening Run No. 1A

Lamefoot Mine Plan, 60-ft Thick, No Eackfill

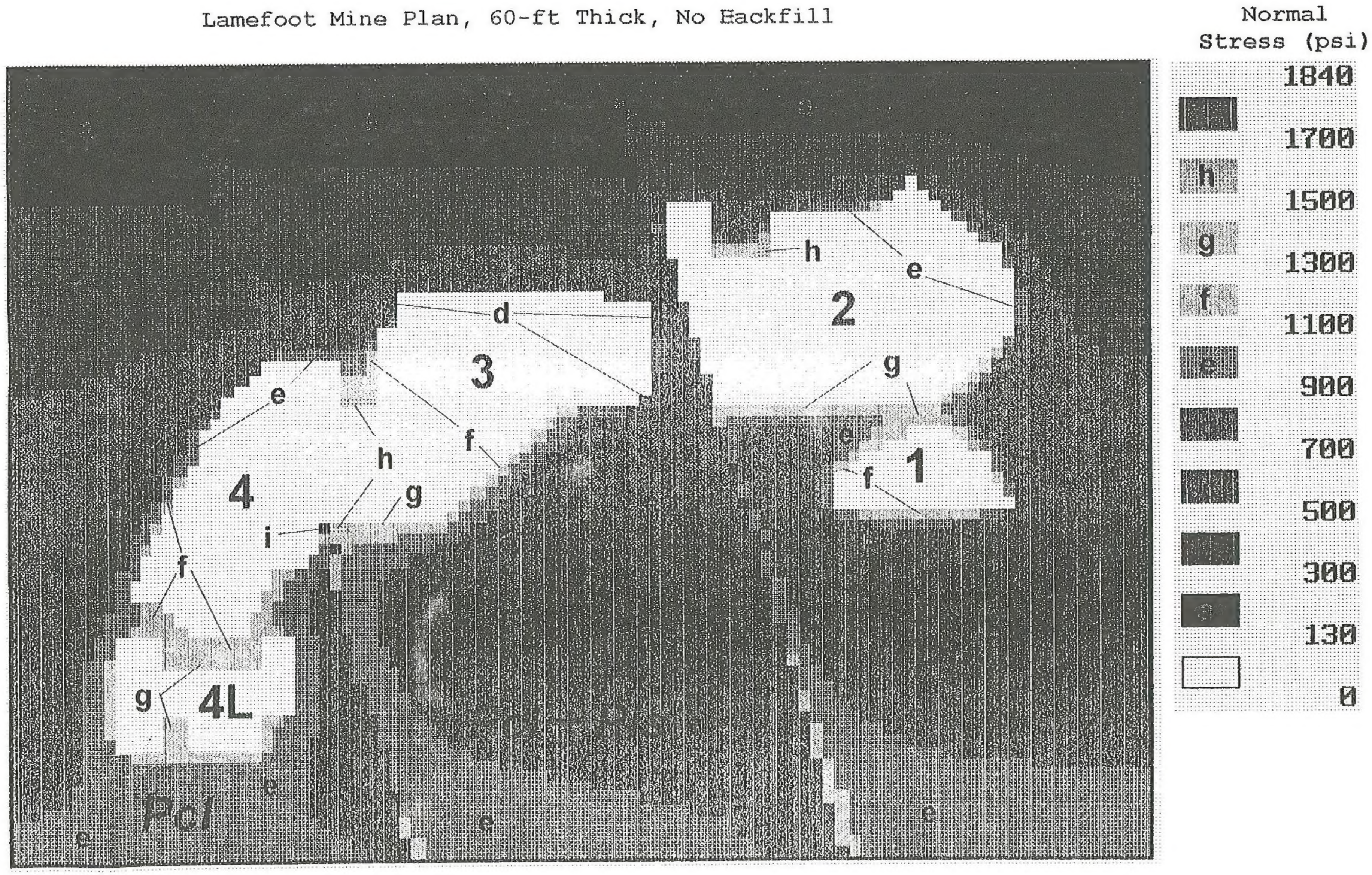


Figure D-1

Echo Bay Mineralls, Inc. Plane of Vein Closure, Strain Softening Run No. 1A

Lamefoot Mine Plan, 60-ft Thick, No Backfill

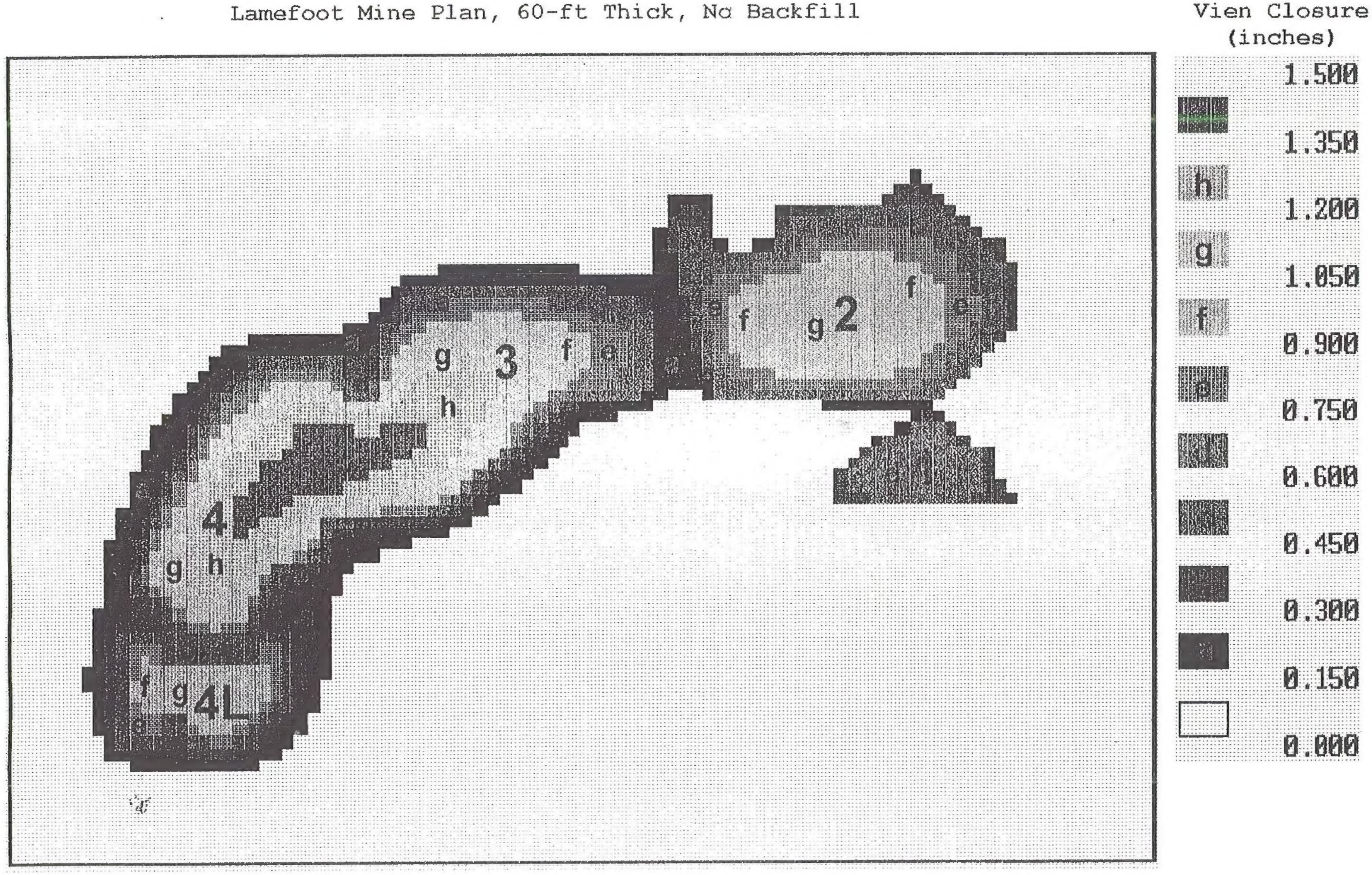
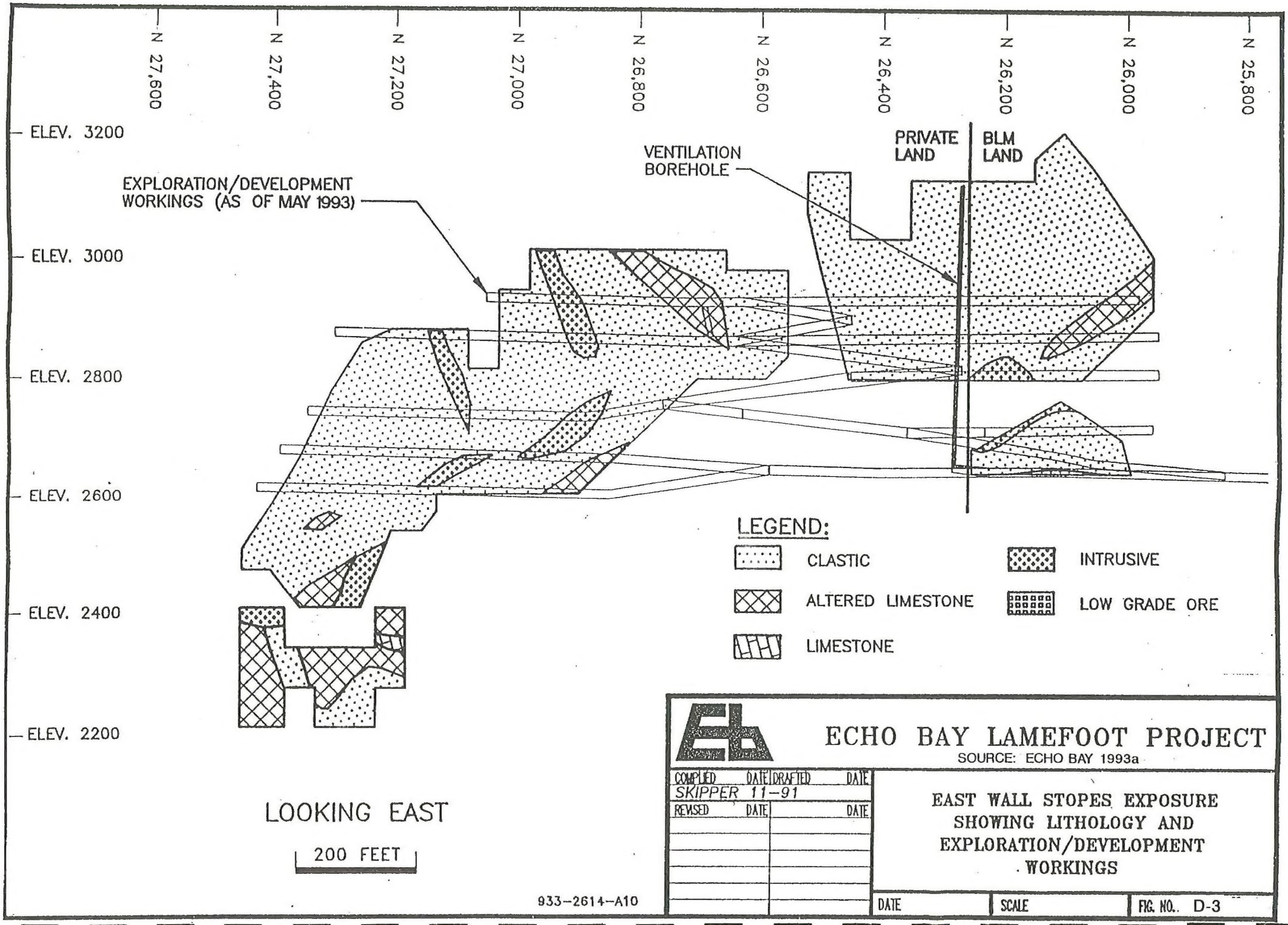


Figure D-2



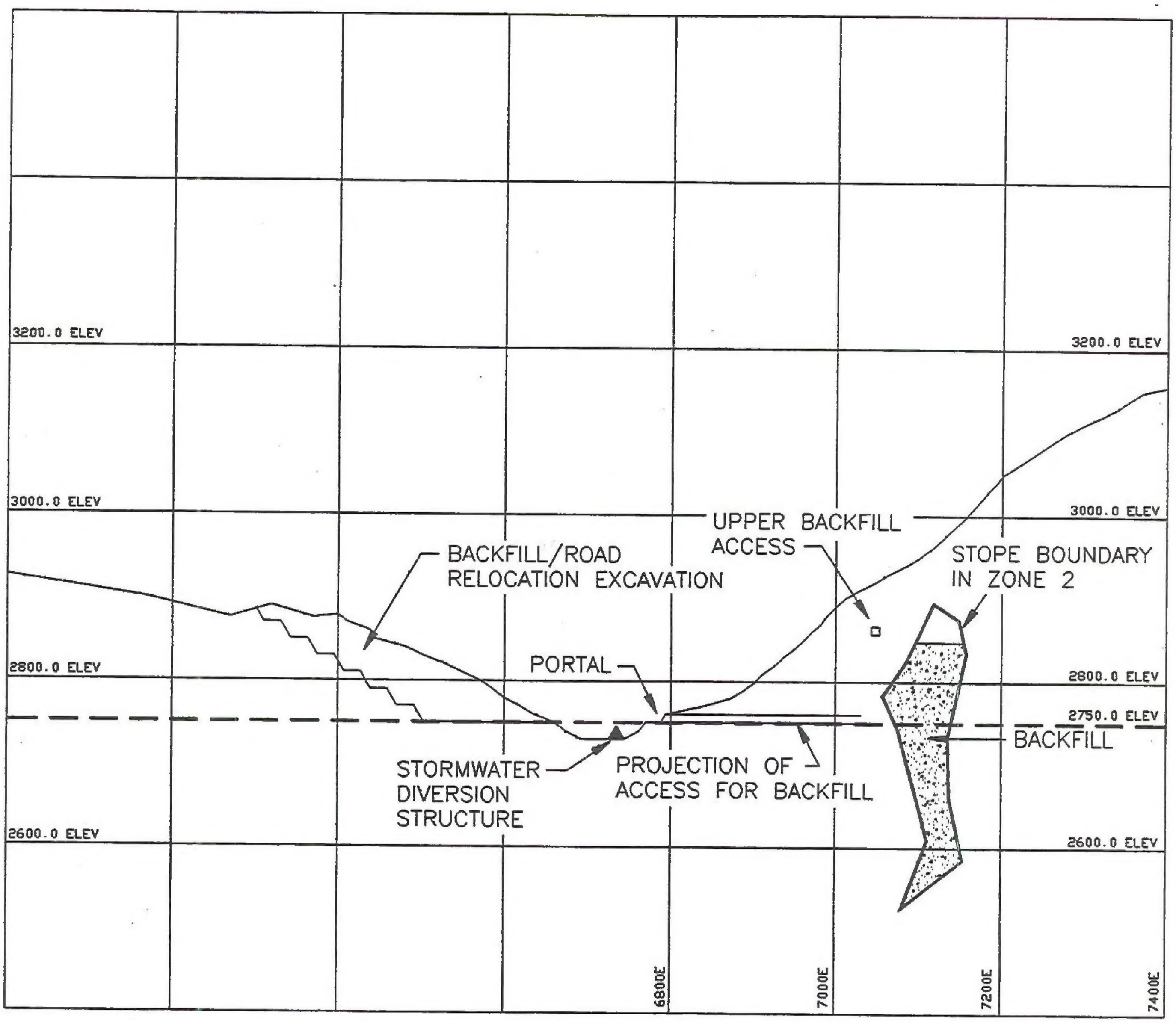
ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

COMPILED	DATE	DRAFTED	DATE
SKIPPER	11-91		
REVISED	DATE		DATE

EAST WALL STOPES EXPOSURE SHOWING LITHOLOGY AND EXPLORATION/DEVELOPMENT WORKINGS

DATE | SCALE | FIG. NO. D-3



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993a

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

GENERALIZED CROSS SECTION OF LAMEFOOT AREA SHOWING BACKFILLED STOPE AND ROAD RELOCATION EXCAVATION

DATE APRIL 93	SCALE 1"=200'	FIG. NO. D-4

SECTION2

APPENDIX E
RECLAMATION PLAN
PREPARED BY ECHO BAY MINERALS, INC., 1993 (REVISED FOR EISS)

APPENDIX E
TABLE OF CONTENTS

Section | Page

1.0 INTRODUCTION E-1

1.1 RECLAMATION SCHEDULE E-1

2.0 GENERAL RECLAMATION PROCEDURES E-3

2.1 COVERSOIL E-3
2.2 FERTILIZATION E-3
2.3 CULTURAL TREATMENTS E-3
2.4 EROSION AND SEDIMENT CONTROL E-4
2.5 GRADING AND STABILIZATION E-5
2.6 REVEGETATION E-5

2.6.1 Coversoil Application E-5
2.6.2 Species Selection E-5
2.6.3 Seeding and Planting E-6
2.6.4 Mulch Application E-7

3.0 RECLAMATION OF DRILL SITES/ROADS E-7

3.1 SLASH CLEARING AND COVERSOIL STRIPPING AND SALVAGING E-7
3.2 ROAD AND PAD RECLAMATION E-7
3.3 STAINING E-8
3.4 DRILL HOLE ABANDONMENT E-8

4.0 RECLAMATION OF DISTURBANCES ASSOCIATED WITH UNDERGROUND EXPLORATION E-9

4.1 SURFACE FACILITIES E-9
4.2 WASTE ROCK DISPOSAL AREA E-10
4.3 UNDERGROUND WORKINGS E-10
4.4 SEDIMENT CONTROL STRUCTURES E-10
4.5 KEY MILL SITE E-11

5.0 TEMPORARY CLOSURE PLAN E-11

6.0 POST CLOSURE MONITORING E-11

6.1 SUBSIDENCE E-11
6.2 ACID GENERATION E-12
6.3 REVEGETATION MONITORING PLAN E-12

7.0 PUBLIC SAFETY E-12

8.0 NOXIOUS WEED CONTROL PLAN E-12

Following Page

9.0 UNDERGROUND RECLAMATION E-13

10.0 BACKFILL QUARRY RECLAMATION (ADAPTED FROM GOLDER ASSOCIATES 1994) E-14

- 10.1 TIMBER HARVEST AND SITE CLEARING E-14
- 10.2 COVERSOIL STRIPPING AND SALVAGE E-14
- 10.3 QUARRY E-14
- 10.4 COUNTY ROAD RELOCATION E-15
- 10.5 CLOSURE CRITERIA E-15

11.0 REFERENCES E-15

LIST OF TABLES

TABLE E-1 COVERSOIL SUMMARY
TABLE E-2 FERRY COUNTY NOXIOUS WEED LIST

LIST OF FIGURES

FIGURE E-1 PROJECT SCHEDULE AND MONITORING EVALUATION
FIGURE E-2 PROPOSED FINAL RECLAIMED TOPOGRAPHY
FIGURE E-3 LOCATION MAP FOR TYPICAL ROAD SECTIONS
FIGURE E-3a TYPICAL ROAD SECTIONS CONTOURS DURING OPERATIONS
FIGURE E-3b TYPICAL ROAD SECTIONS FINAL RECLAIMED CONTOURS
FIGURE E-4 FACILITY LAYOUT
FIGURE E-5 CONCEPTUAL DIAGRAM OF PORTAL #1 ADIT CLOSURE
FIGURE E-6 CONCEPTUAL DIAGRAM OF PERMANENT SHAFT CLOSURE
FIGURE E-7 CONCEPTUAL DIAGRAM OF OLD TIMER'S ADIT A CLOSURE
FIGURE E-8 CONCEPTUAL DIAGRAM OF OLD TIMER'S ADIT B CLOSURE
FIGURE E-9 CONCEPTUAL DIAGRAM OF BACKFILL CROSS CUT CLOSURE
FIGURE E-10 BACKFILL QUARRY AND COUNTY ROAD DIVERSION
FIGURE E-10a RELOCATED COUNTY ROAD SECTION 1 PLAN AND PROFILE
FIGURE E-10b RELOCATED COUNTY ROAD SECTIONS 2 AND 3 PLAN AND PROFILE
FIGURE E-10c RELOCATED COUNTY ROAD SECTIONS 4 AND 5 PLAN AND PROFILE
FIGURE E-10d RELOCATED COUNTY ROAD SECTION 6 PLAN AND PROFILE

APPENDIX E
RECLAMATION PLAN
PREPARED BY ECHO BAY MINERALS, INC., 1993 (REVISED FOR EISS)

1.0 INTRODUCTION

This plan presents reclamation activities for final mine closure and summarizes the reclamation activities previously approved by the BLM for the exploration drill pads. BLM lands disturbed by project activities constitute a small portion of the total disturbance. Most surface and subsurface disturbance is located on private land controlled by Echo Bay. This reclamation plan has been prepared to describe the reclamation of the BLM lands. Reclamation plans for private lands are also being provided for completeness.

Echo Bay will reclaim disturbance where conditions and current reclamation technology permit, and as required by BLM, state, and county regulations. Historical and current land uses include livestock grazing, wildlife habitat, forest management, and mineral extraction. The goal of reclamation is to return the federal land at the site to a post-mining condition which is consistent with the preferred BLM alternatives for forest, wildlife, and recreation management (BLM 1985, BLM 1994).

Reclamation plans with regard to mining activities on BLM administered lands are similar to those already approved and successfully used by Echo Bay in past activities, and are discussed below as they pertain to road building, concurrent reclamation, interim reclamation, and final reclamation of the disturbed areas. Reclamation plans presented here are, to the extent applicable and appropriate, based on guidelines contained in the BLM Reclamation Handbook (BLM 1992b).

Echo Bay's proposed post-mining land use is for wildlife habitat. The reclamation species mix will return the surface facilities to the predominant bluebunch wheatgrass (*Agropyron spicatum*)/Idaho fescue (*Festuca idahoensis*) grassland community which the site supported prior to disturbance. The species proposed will provide initial site stabilization to prevent erosive soil loss and provide browse for wildlife. The mosaic of open grassland and timbered stands will be well suited to provide the diversity of cover, edge, and browse which provide deer with winter range.

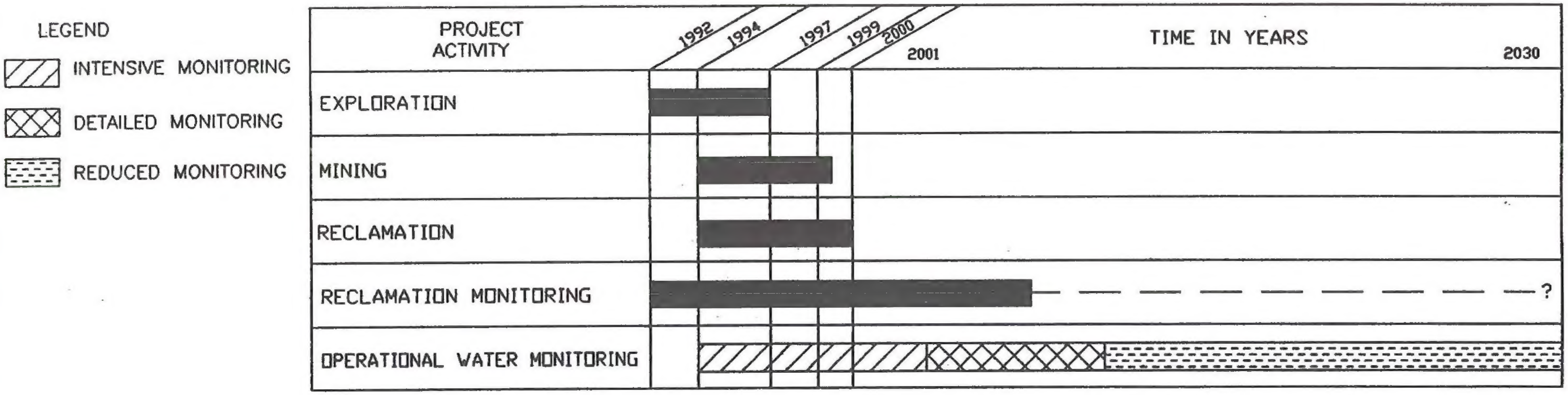
1.1 RECLAMATION SCHEDULE

Reclamation activities will be scheduled to occur as soon as practical after the mining activities are completed, thus minimizing erosion and sedimentation problems (see Figure E-1). In general, reclamation activities will be timed to take advantage of optimal climatic conditions. Final grading, drainage, and sediment control establishment will occur over the late spring and summer months. Seedbeds will be prepared in late summer or early fall, just prior to seeding. Seeding will be completed in mid to late fall in order to take advantage of winter and spring moisture. If seeding is not completed prior to the onset of winter, or if fall seeding is unsuccessful, early spring seeding could occur as an alternative.

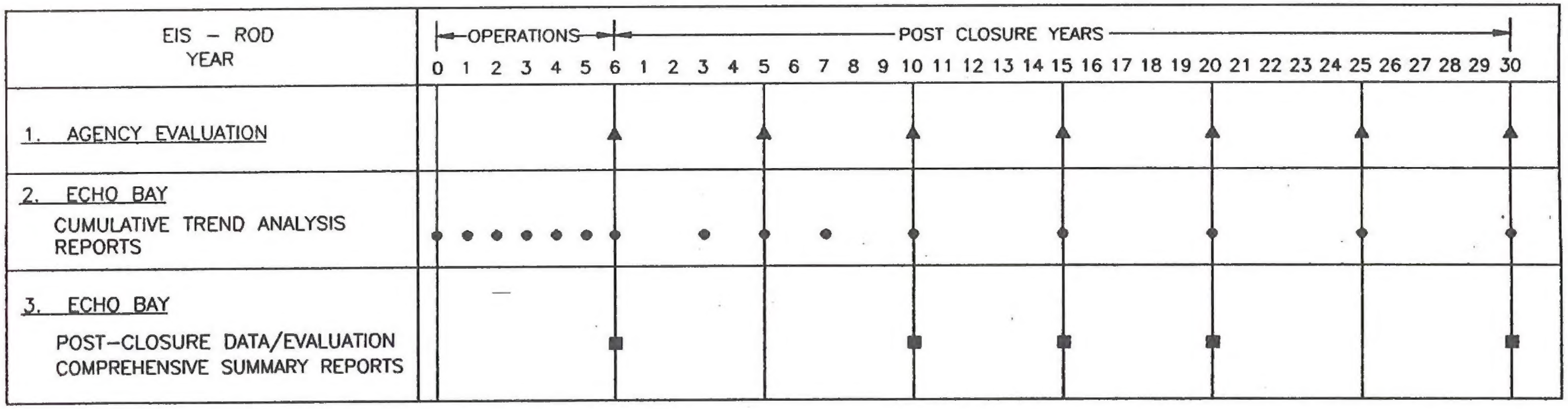
Many of the reclamation activities can not occur until near the time of final mine closure. Areas such as underground workings and surface facilities associated with exploration will remain active until mine closure. However, during the anticipated life of the project, interim and concurrent reclamation will occur to reduce erosion and the potential for off-site degradation.

Interim reclamation refers to reclamation efforts on lands disturbed during the course of a project that, while not at final reclamation contours, will not be redisturbed for a significant time period and, therefore, require interim stabilization. To reduce erosion and sedimentation during the life of the operation, disturbed areas will be temporarily revegetated. For all areas subject to interim reclamation requirements, slopes will be

PROJECT SCHEDULE AND MONITORING PLAN



MONITORING EVALUATION SCHEDULE



NOTES:

1. ADDRESSES NEEDED CHANGES TO:
   - MONITORING PROGRAM (PROBLEM IDENTIFICATION, FUTURE ACTIVITIES)
   - BONDING REQUIREMENTS
   - FURTHER EVALUATION METHODS
2. CUMULATIVE TRACKING AND RECORD KEEPING OF INDICATOR AND OTHER PARAMETERS.
3. INCLUDE CUMULATIVE EVALUATIONS OF ANNUAL REPORTS FROM BASELINE TO PRESENT, AND CONCEPTUAL HYDROGEOLOGICAL/WATER QUALITY/GEOCHEMICAL EVALUATIONS.

ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LAMEFOOT MINE
PROJECT SCHEDULE
AND MONITORING EVALUATION

DATE: JUNE 1994 | SCALE: NA | FIG. NO. E-1

LPS001

reduced as much as feasible; the surface will be appropriately prepared/tilled to receive broadcast seed, starter fertilizer (16-48-37) will be applied, and the seeded areas will be dragged to facilitate burial. These measures will minimize the potential for accelerated erosion and will optimize conditions for successful establishment of the interim vegetative cover. Straw mulch will be applied, as required, at a rate of 2 tons per acre on slopes in excess of 15 percent but less than 30 percent. The straw will be crimped into the soil surface on the contour. On slopes in excess of 30 percent, straw mulch will be applied at a rate of 1.5 tons per acre and sprayed with an agency-approved tackifier; netting will be applied and stapled over straw mulch for specific areas of concern such as highly erodible soils placed on steep slopes in excess of 50 percent. Salvaged coversoil will not be used in interim revegetation unless readily available. On private lands, interim reclamation areas will be broadcast-seeded at rates of 25 to 40 pounds pure live seed (PLS) per acre, with an interim seed mixture consisting of the following:

• 60% Luna pubescent wheatgrass	(*Agropyron trichophorum* var. Luna)
• 30% Sherman big bluegrass	(*Poa ampla* var. Sherman)
• 5% alfalfa	(*Medicago sativa*)
• 5% white Dutch clover	(*Trifolium repens*)

This seed mix was recommended by U.S. Soil Conservation Service personnel. The higher rate will be used on difficult sites, such as on the face above the adit entrance. Seed, fertilizer, and mulch will again be added on both public and private lands if initial seeding is unsuccessful. The cover soil stockpiles will require interim reclamation.

On federal lands, interim reclamation areas will be broadcast-seeded at rates of 25 to 40 pounds PLS per acre, with an interim seed mixture consisting of the following native species:

- 30% mountain brome (*Bromus marginatus*)
- 30% slender wheatgrass (*Elymus trachycaulus*)
- 20% Idaho fescue (*Festuca idahoensis*)
- 20% bluebunch wheatgrass (*Agropyron spicata*)

Concurrent reclamation refers to reclamation activities which can be carried on at the same time as ongoing mining activities. Concurrent reclamation can be advantageously employed on disturbed areas that have served their purpose and are ready to be graded to final reclamation contours. Such areas will include disturbance associated with the Wolfe Camp Road relocation and diversion ditches. Drill pads and access roads may be reclaimed concurrently if it is determined that they are not needed for future activities. Where possible, during the life of the Lamefoot Project, disturbed lands will be reclaimed concurrently with ongoing mining operations, using final reclamation procedures.

Most reclamation activities will take place at the time of mine closure and will be considered final reclamation. The areas to undergo reclamation at mine closure will include waste rock disposal areas, the underground workings and associated surface facilities, and any drill pads and access roads which will be needed until mining ceases. Final reclamation will be implemented upon the completion of mining and exploration; these procedures are discussed below in detail.

2.0 GENERAL RECLAMATION PROCEDURES

This section includes the general steps to be followed in reclaiming each of the disturbance areas.

2.1 COVERSOIL

The use of suitable coversoil is a critical component of the revegetation plan and will enhance the recovery of reclaimed mine facilities. Coversoil is defined as the soil of the A and B horizons or referred to as all suitable solum materials that will sustain plant growth. Coversoil will be used to facilitate revegetation of areas disturbed by the mining operation.

2.2 FERTILIZATION

Disturbance areas associated with exploration at Lamefoot and other areas of the Kettle River Project have been revegetated successfully without fertilization. Based on these results, it is anticipated that fertilization may not be necessary. Native species are better adapted to low levels of available nutrients. However, fertilizer at a rate of 50 lbs N/acre, 100 lbs P/acre, and 60 lbs K/acre will be applied to areas where nutrient deficiencies are observed in the re-established vegetation. Fertilizer will also be applied to critical revegetation areas such as slopes in excess of 50 percent. Care will be taken immediately after any necessary fertilization efforts to ensure existing erosion control features/measures are in place and prepared to limit runoff into springs and wetlands during a storm event (Section 2.4).

Samples will be taken from each mine facility (waste rock disposal areas, surface facilities, drill pads and exploration roads, and coversoil stockpiles) to characterize baseline physical and chemical plant growth conditions prior to reclamation activities. If nutrient deficiencies are indicated by revegetation monitoring, Echo Bay will add fertilizer to facilitate the establishment of seeded species. General fertilization guidelines (Soltanpour et al. 1985) indicate that plant growth material containing less than 6 ppm N, 10 ppm P, and 60 ppm K will require supplemental fertilizer for plant growth. A typical fertilization program will include approximately 50 lbs N/acre, 100 lbs P/acre, and 60 lbs K/acre if soil analysis indicates deficiencies. If fertilizer is required, care will be taken to avoid the establishment of a plant community which is dependent on high nutrient levels.

2.3 CULTURAL TREATMENTS

Cultural treatments typically refer to soil-modification practices that create more favorable conditions to facilitate plant growth by: (1) initiating and maintaining a stable soil system, (2) reducing erosion of surface soils, (3) increasing soil moisture and reducing evaporative losses, (4) extending the season of seeding by moderating local microclimates, and (5) modifying microenvironments to create a more diverse plant community. Typical cultural treatments that can be used to facilitate plant community development include soil ripping, tilling, harrowing, seedbed preparation, mulching, and erosion control measures. All mine units which are compacted (i.e., roads, level surfaces on waste rock disposal areas, and surface facilities) will be deep-ripped with bulldozer-mounted ripper bars or a chisel plow to a depth of 12 to 18 inches, in order to loosen the plant-rooting zone, create an adhesive surface for the coversoil application, and incorporate fertilizer materials. Deep ripping will increase infiltration by decreasing the bulk density, thus reducing runoff and erosion from the reclaimed slopes. Scarification (shallow ripping to 8 to 10 inches) will be conducted on mine units which do not have deep subsoil compaction. Ripping on any reclaimed slopes will occur parallel to the contours, where possible. On slopes with subsoil compaction that are too steep to be worked on the contour, ripping will occur perpendicular to the contours, and a chain drag will be attached behind the ripper to eliminate furrows and to reduce erosion due to channelized flow. Coversoil application on slopes will result in a loose soil surface that is a receptive seed germination environment.

2.4 EROSION AND SEDIMENT CONTROL

Erosion control will be accomplished by the two existing diversion channels which collect runoff from upgradient of the surface facilities. The diversion ditch channels flow to two infiltration ponds located in the southern and northeastern parts of the surface facilities. Sedimentation ponds will be monitored at least once per month during the summer months, weekly during spring snowmelt, and following large precipitation events. Sedimentation ponds will be cleaned, as necessary, using a backhoe. Sediment removed from the ponds will be added to the coversoil stockpiles. Diversion ditches and infiltration ponds will be backfilled with sidecast or materials excavated from the ditches or ponds during construction.

Sediment control structures will be placed in ditches and below unrevegetated slopes to aid in erosion and sediment control, as necessary. Hay bales, silt fences, matting, and other sediment management practices will be used to aid in erosion and sediment control. Only hay that is free of noxious weeds will be used, reducing the potential for establishment of noxious weeds. Erosion and sediment control measures also include soil handling and grading techniques to enhance stability and reduce sedimentation, and revegetation practices to provide soil-stabilizing vegetation cover.

Water handling measures to control runoff and sedimentation during operations, and until revegetation has been successfully established, include:

- The disturbed area will be kept to a minimum at any given time through interim and concurrent reclamation.
- Drainage structures constructed on access and haul roads will include properly installed channels, water bars, cross drains, culverts, sediment traps, and silt fencing.
- Rapidly developing species are included in the seed mixture to provide rapid stabilization.
- Topsoil redistribution and revegetation will occur in the first appropriate season after cessation of mining.
- Mulch (and tackifiers on hydroseeded areas) will be applied to aid in erosion control and moisture retention, as necessary. It is anticipated that mulch will be applied to topsoil stockpiles and to slopes steeper than 15 percent.
- Revegetated areas will be protected from disturbance by placing signs and barriers to restrict traffic until vegetation is established.
- Interim revegetation will be used to stabilize coversoil stockpiles.

Grading during reclamation will be designed and conducted to minimize the potential for erosion, and measures include:

- Reclaimed slopes will be inspected periodically. Any rills and gullies that develop will be stabilized and revegetated by backfilling, hand compacting, and seeding with the interim seed mixture.
- Fill slopes and other potential sediment sources will be visually inspected throughout the operation to allow early detection of erosion and vegetation problems. During critical runoff periods, such as the spring snowmelt, inspection of some layer fills and erodible areas will be on a more frequent basis.

- Road grades have been designed such that natural drainage patterns are disrupted as little as possible.

2.5 GRADING AND STABILIZATION

Slopes will be shaped for reclamation upon completion of the active life of each project component. Depending on the type of material, erodibility, and the practical considerations of the mining process, overall slope grades will vary. Grading will be accomplished using bulldozers. Figure E-2 presents the proposed final topography following reclamation of the facilities area.

Loose faces of slopes which are accessible will be "walked" with a dozer to partially compact the surfaces prior to coversoil placement. Haul and access roads to be reclaimed will be graded or have the edge berm pulled back prior to revegetation. In addition, compacted surfaces such as roads, parking areas and building areas, will be ripped or scarified (as discussed in Section 2.3) prior to coversoil placement and revegetation.

2.6 REVEGETATION

2.6.1 Coversoil Application

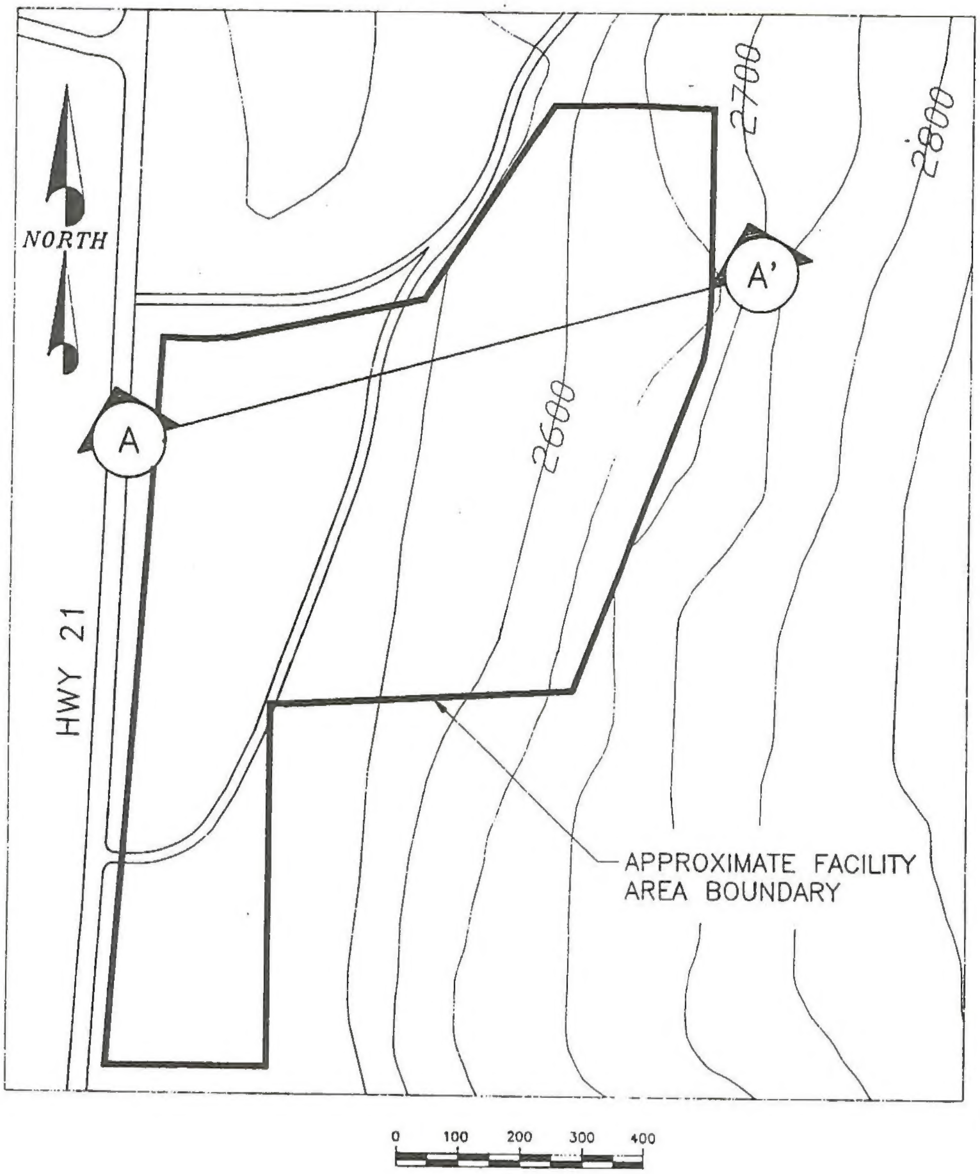
Prior to coversoil replacement, composite samples will be taken from each stockpile. The samples will be analyzed for texture, organic material, pH, and available macro and micro-nutrients. The analyses will be conducted at an approved state agricultural laboratory which will provide a fertilizer recommendation in addition to reporting analytical results. Coversoil will be placed on all reclaimed areas to provide growth medium for revegetation.

2.6.2 Species Selection

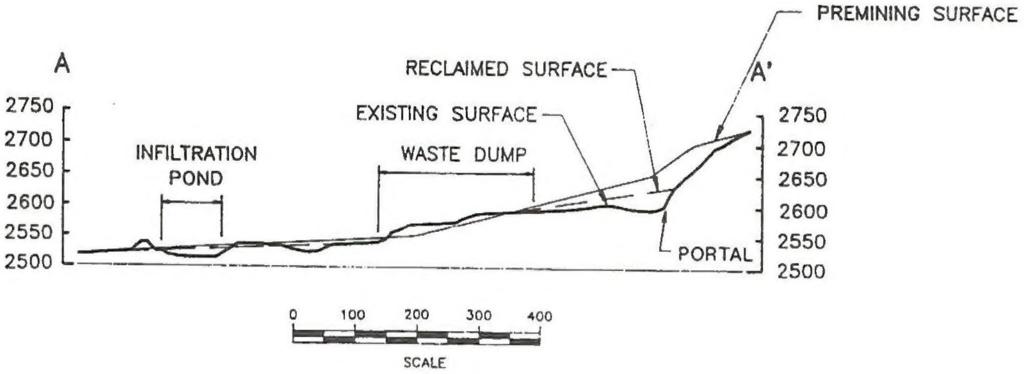
The selection of appropriate grass and forb species for revegetation, and appropriate sources of plant materials, is a critical process which controls the function of the overall revegetation program. All species included in the proposed seed mixtures are adapted to the area. Species selection was based on proposed land use, climate, and soil conditions. Specific seed sources will be selected to ensure that the plants are adapted to the elevation, precipitation, temperature, and soil conditions present at the Lamefoot site.

The species mixture chosen for revegetation is designed to provide a stable environment that is capable of supporting pre-mining land uses of wildlife habitat, recreation, and mineral exploration. All species selected for revegetation at the site are adapted to low fertility environments. Species that are adapted to low nutrient conditions are better suited to compete with aggressive weedy species during the critical plant establishment period. The utilization of adapted species and careful fertilization techniques will ultimately result in a plant community composed of species that can survive lower nutrient conditions, yet out-compete aggressive weedy invaders that require higher nutrient conditions. Manual spot applications of appropriate herbicides will be used to control limited outbreaks of noxious weeds in order to minimize loss of desirable forbs and shrubs (see Section 3.9). Seeds are available from suppliers in Washington State, and seedlings are available from suppliers in the Pacific Northwest who specialize in reclamation. Echo Bay will obtain seeds from established seed supply companies which produce seed adapted to the conditions at the Lamefoot site. Echo Bay will specify that plant materials originate from an elevation range of 2,500 to 3,500 feet and an average annual precipitation of 15 to 25 inches. If appropriate seed sources are not available, with adequate lead time, most seed distributors will collect appropriate seed sources as required for a given revegetation request.

The approved seed mixture proposed for use on private lands was developed by project soils and vegetation specialists in consultation with the Soil Conservation Service (SCS), BLM, and U.S. Forest Service (USFS)



SCALE: 1" = 200'



SCALE: 1" = 200'
NO VERTICAL EXAGGERATION

ECHO BAY LAMEFOOT PROJECT

ECHO BAY MINERALS CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

PROPOSED FINAL RECLAIMED TOPOGRAPHY OF THE LAMEFOOT FACILITIES AREA

DATE	SCALE	FIG. NO.
MAY 1993	1"=200'	E-2

FILE: B-16

(Colville National Forest, Republic Ranger District) personnel for this and similar sites in the area. The seed mixture and broadcast application rate consists of:

•	2 lb PLS/acre	white Dutch clover (*Melilotus alba*)
•	4 lb PLS/acre	smooth brome (*Bromus inermes*)
•	4 lb PLS/acre	orchard grass (*Dactylis glomerata*)
•	4 lb PLS/acre	Sherman big bluegrass (*Poa ampla* var. Sherman)
•	4 lb PLS/acre	bluebunch wheatgrass (*Agropyron spicatum*)
•	4 lb PLS/acre	Idaho fescue (*Festuca idahoensis*)

The first four species are recommended because of their ability to colonize and quickly stabilize the soil on disturbed sites. The last two species are native to the Lamefoot area and will ultimately become the dominant species in the revegetated areas. However, these species are slow to colonize and, therefore, are not recommended for use alone in revegetation seed mixtures where erosion control is the overriding concern for the first year or two of growth.

The seed mixture and broadcast application rates for final reclamation of federal lands consists of:

•	3 lbs PLS/acre	mountain brome (*Bromus marginatus*)
•	3 lbs PLS/acre	slender wheatgrass (*Elymus trachycaulus*)
•	5 lbs PLS/acre	Idaho fescue (*Festuca idahoensis*)
•	5 lbs PLS/acre	bluebunch wheatgrass (*Agropyron spicata*)
•	2 lbs PLS/acre	canby bluegrass (*Poa canbyi*)
•	1 lb PLS/acre	serviceberry (*Amelanchier alnifolia*)
•	1/2 lb PLS/acre	Utah sweetvetch (*Hedysarum boreale*)
•	1/2 lb PLS/acre	silky lupine (*Lupinus sericeus*)
•	1/2 lb PLS/acre	arrowleaf balsamroot (*Balsamorhiza sagittata*)

The first two short-lived species are recommended for their seedling vigor and rapid establishment qualities. The next three species will likely become the dominant species as they are long-lived and are native to the Lamefoot area. The last four are included for diversity.

2.6.3 Seeding and Planting

If possible, all seeding and planting activities will be conducted in the fall at the conclusion of regrading, placement of coversoil, fertilization, and seedbed preparation. Seeding is most effective when completed prior to the period of peak precipitation. If fall seeding is unsuccessful, areas will be re-seeded in the spring. Seedbed preparation will be accomplished using an agricultural disk on the contour, when feasible. The surface of the prepared seedbed will be left relatively rough to create microsites to facilitate burial of seed and establishment of seedlings. Seed will be broadcast with a cyclone-type broadcaster on accessible sites, and by means of hand broadcasting and hydroseeding on steep slopes, as access allows. The seedbed will be harrowed or dragged following seeding to ensure proper seed burial. Broadcast seeding techniques will be used on all disturbed areas to create a more natural-appearing plant community. Broadcast seeding disperses seed over the soil surface in a random pattern. This provides a more natural-appearing plant community than drill seeding, which plants seeds in straight lines at fixed intervals.

2.6.4 Mulch Application

Straw mulch will be applied, based on criteria established in Section 1.1, to seeded areas immediately after seeding to facilitate plant-community development, and to protect the seeded areas from wind and water erosion until the plants have become established. Mulch provides a favorable plant growth environment by maintaining effective soil temperatures to enhance germination and by conserving moisture in the soil profile for plant use.

3.0 RECLAMATION OF DRILL SITES/ROADS

Reclamation of the Lamefoot drill sites and access roads will be performed incrementally. Those areas likely to be needed for access to ongoing exploration and/or full-scale mining activities will not be reclaimed until those activities are completed. However, adequate drainage patterns, erosion control berms, cresting of road surfaces, or construction of water bars will be established on these unreclaimed areas so as to avoid formation of erosion rills or gullies. Barriers and signs will be placed on reclaimed roads to discourage use by off-road vehicles (ORVs) on both private and public lands.

3.1 SLASH CLEARING AND COVERSOIL STRIPPING AND SALVAGING

In selecting the exact drill pad locations for possible future exploration activity, Echo Bay will conduct its activities as previously permitted. Echo Bay will choose as many open areas as possible in order to minimize the disturbance to mature trees.

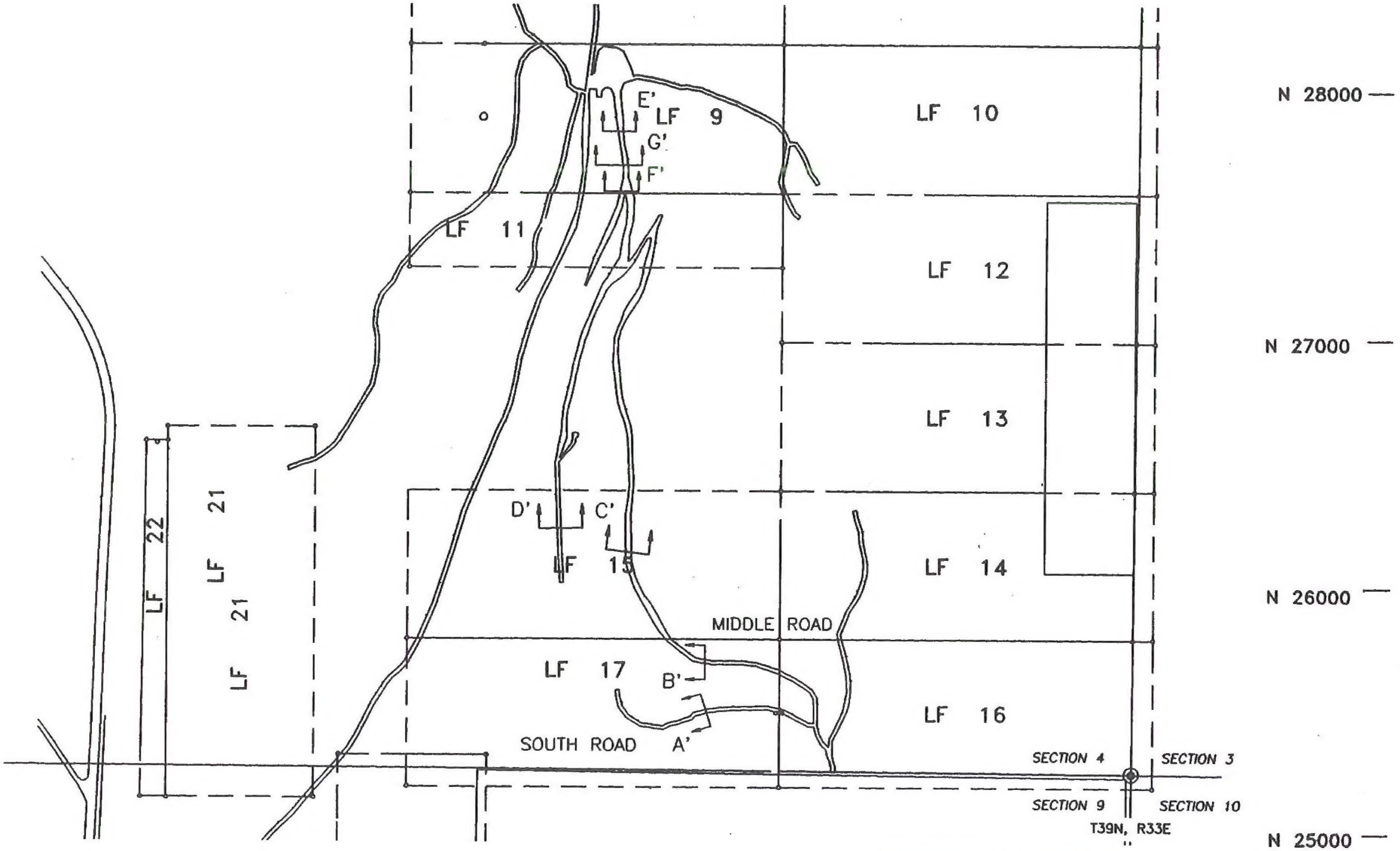
In the past, any slash that was present was isolated, piled, and left in place for establishment of microenvironments for rodents and small mammals. Where practical, coversoil (growth medium) was stripped to a depth of 12 inches from areas of the roads and drill pads. A total of 3,865 cubic yards of material was salvaged and stored in small stockpiles adjacent to each pad site or as sidecast along roadways. In areas where coversoil is to remain in storage for a period exceeding six months, the stockpiles are seeded with the temporary seed mixture.

3.2 ROAD AND PAD RECLAMATION

Recontouring of drill pads to approximately pre-disturbance contours will be done to the extent possible at all Lamefoot sites whether on federal or private land. Many of the sites in flatter terrain will not require recontouring but may require coversoil addition. In areas with moderate slopes, recontouring can be accomplished by salvaging sidecast deposited during road construction. In areas with very steep slopes, some additional material will necessarily be imported in order to recontour.

Recontouring procedures for drill roads with cuts will be determined by the steepness of slopes, height of cuts, and size of sidecast. On gentler slopes, where roads occur in unconsolidated material, a bulldozer will be used along contours to reshape cuts by pushing up sidecast material. In areas with moderate slopes, a track-mounted excavator with a 16-foot reach will be used along contours to pull up sidecast prior to reshaping with the CAT. In areas too steep for sidehill operations of the CAT, the excavator will place the material and compact it using the bucket. These techniques will be used on all disturbance in areas identified in the 1992 Lamefoot Plan of Operations (Echo Bay 1992a) as B,C,D,E and F. It is anticipated that areas A and G will require no recontouring. Figures E-3, E-3a, and E-3b show before-and-after reclamation contours.

Revegetation will use the seed mixtures presented in Section 2.6.2. Seeding will take place in the fall immediately following coversoil placement; and the surfaces will be broadcast-seeded and mulched using the techniques described in Section 1-1 and Section 2.6.3.



ECHO BAY LAMEFOOT PROJECT

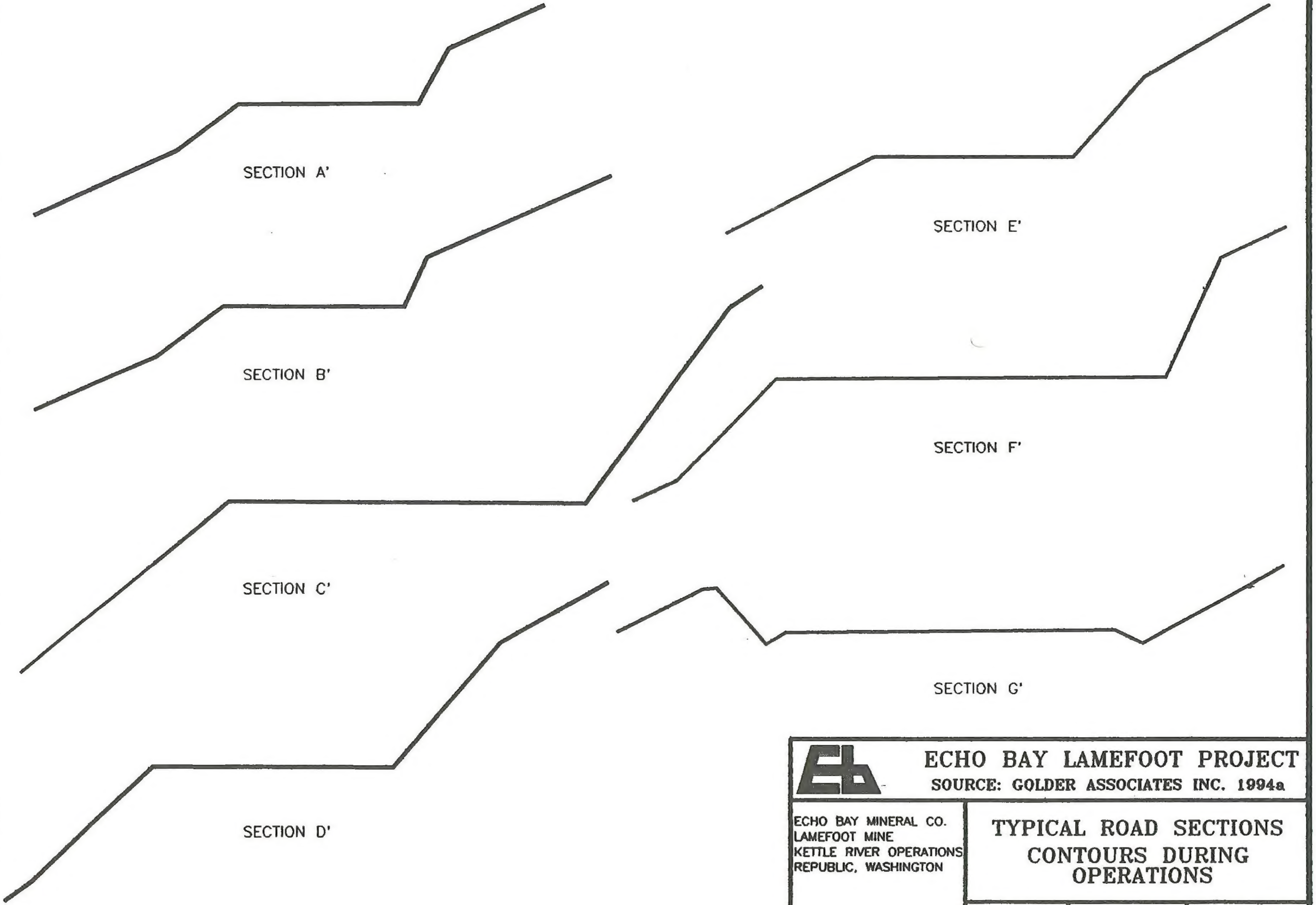
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

LOCATION MAP FOR TYPICAL ROAD SECTIONS

DATE: MAY 1994	SCALE: 1" = 600'	FIG. NO. E-3

SECLOCMP



ECHO BAY LAMEFOOT PROJECT

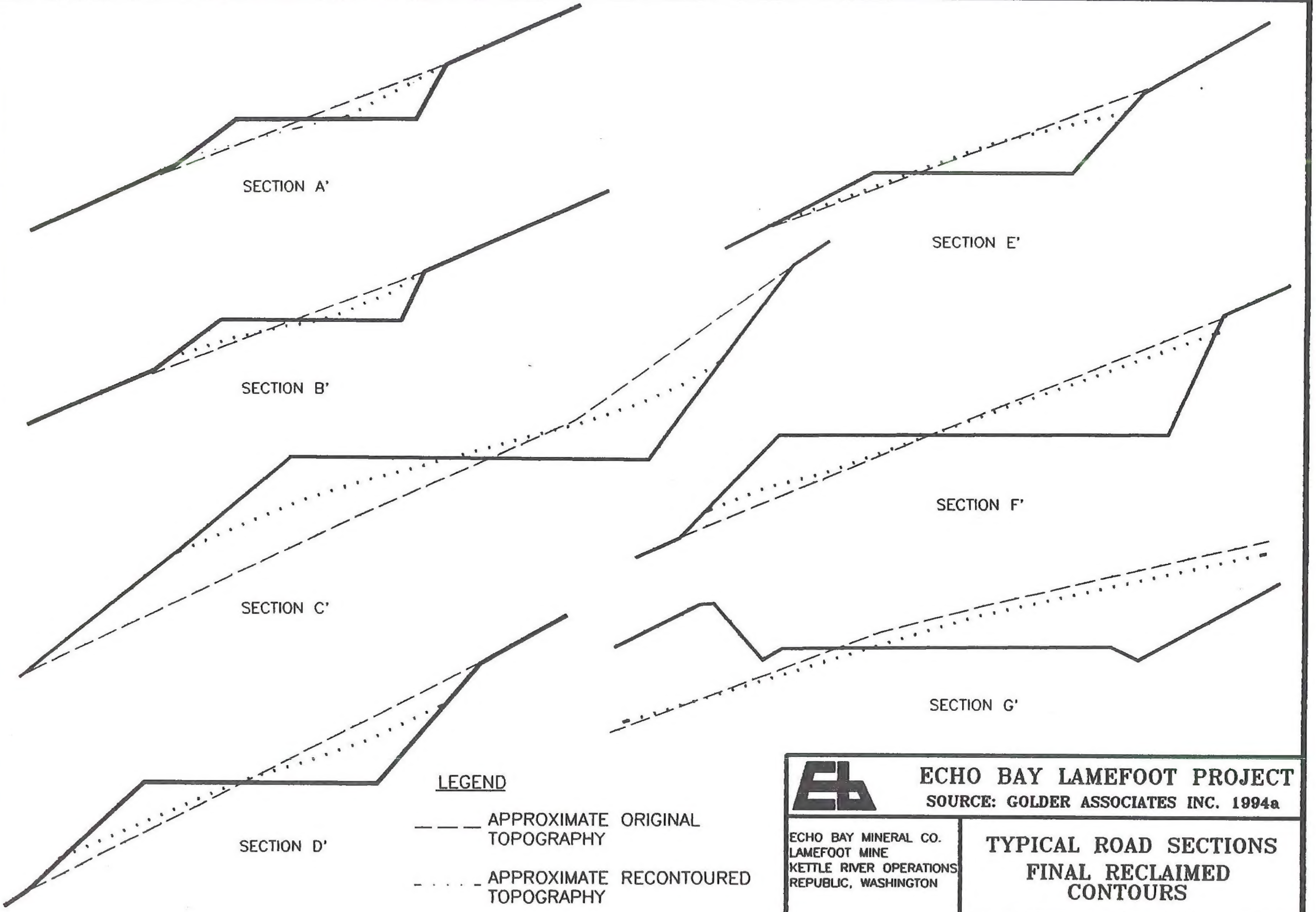
SOURCE: GOLDER ASSOCIATES INC. 1994a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

TYPICAL ROAD SECTIONS CONTOURS DURING OPERATIONS

DATE: MAY 1994	SCALE: 1" = 10'	FIG. NO. E-3a

LAMTRS


SECTION A'
SECTION B'
SECTION C'
SECTION D'
SECTION E'
SECTION F'
SECTION G'
LEGEND
— — — APPROXIMATE ORIGINAL TOPOGRAPHY
- · · · · APPROXIMATE RECONTOURED TOPOGRAPHY

ECHO BAY LAMEFOOT PROJECT

SOURCE: GOLDER ASSOCIATES INC. 1994a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

TYPICAL ROAD SECTIONS FINAL RECLAIMED CONTOURS

DATE: MAY 1994 | SCALE: 1" = 10' | FIG. NO. E-3b

LAMTRS1

Concurrent reclamation will be performed on the middle and upper exploration roads in the area identified in the 1992 Lamefoot Plan of Operations (Echo Bay 1992a) as H. These roads will be reclaimed, when they are no longer needed, by pushing the existing berm to the inside of the road with a D-6 or D-7 CAT excavator, which will then pull sidecast onto the road. The CAT will push the reclaimed sidecast toward the end of the road, flattening it, as required for subsequent steps. Next, fill will be brought in by dump trucks and the excavator will place the fill and reshape topography to the extent possible. Fill material will consist of glacial gravel from site construction or broken rock from underground or surface excavation. Prior to placement of coversoil, a base application of fertilizer will be placed on the surface of the replaced waste rock. This will be done in short increments no longer than the reach of the excavators' arm. When each segment is finished, coversoil will be brought in and placed in a similar manner. This procedure will be repeated until the entire road length on BLM land is complete. Coversoil will be placed to a depth of approximately eight inches. The surface will be revegetated using the seed mixture presented in Section 2.6.2.

To protect public safety, some portions of Area H will remain unreclaimed where rock slopes are too steep to revegetate. This determination will be at the discretion of the field personnel. If open to traffic during this reclamation, the existing Wolfe Camp Road will be intermittently closed by flaggers to avoid the hazard of rolling rocks dislodged by the reclamation effort.

The steep slope above the Wolfe Camp Road is presently being stabilized through the use of screens. Additional activities to stabilize the slopes above Wolfe Camp Road are discussed in Section *4.3*.

3.3 STAINING

Echo Bay will experiment with rock staining to determine if natural looking results can be accomplished with the rock type present in the project area. Should the results of the staining tests be judged successful, exposed rock faces in Area H and other appropriate visible rock faces will be stained within the first two seasons of operations to reduce the visual contrast between the fresh cut rock surfaces and the natural landscape.

The stain will be an environmentally safe solution that is sprayed on the rock cuts that, over a one-week period, develops into earth-tone colors that can be varied by using different spray patterns and concentrations.

3.4 DRILL HOLE ABANDONMENT

Completed drill holes are and will be abandoned during reclamation using the methods specified by WAC 173-160 Minimum Standards For Construction and Maintenance Of Wells. Prior to capping, all holes will be filled with a drill hole abandonment fluid consisting of a premium-grade bentonite mixed to a +50 viscosity. The surface casing will be pulled or cut off, and the top 20 feet of the hole will be cemented. If artesian water is encountered in a hole, that hole will be cemented from the bottom (T.D.) to the top (collar).

Accessible drill holes which intersect underground workings during exploration and production will be cemented if they promote an inflow of water.

4.0 RECLAMATION OF DISTURBANCES ASSOCIATED WITH UNDERGROUND EXPLORATION

4.1 SURFACE FACILITIES

Appurtenant surface facilities have been constructed on private land, in association with underground exploration. These facilities will be removed and the surface disturbance will be reclaimed at mine closure.

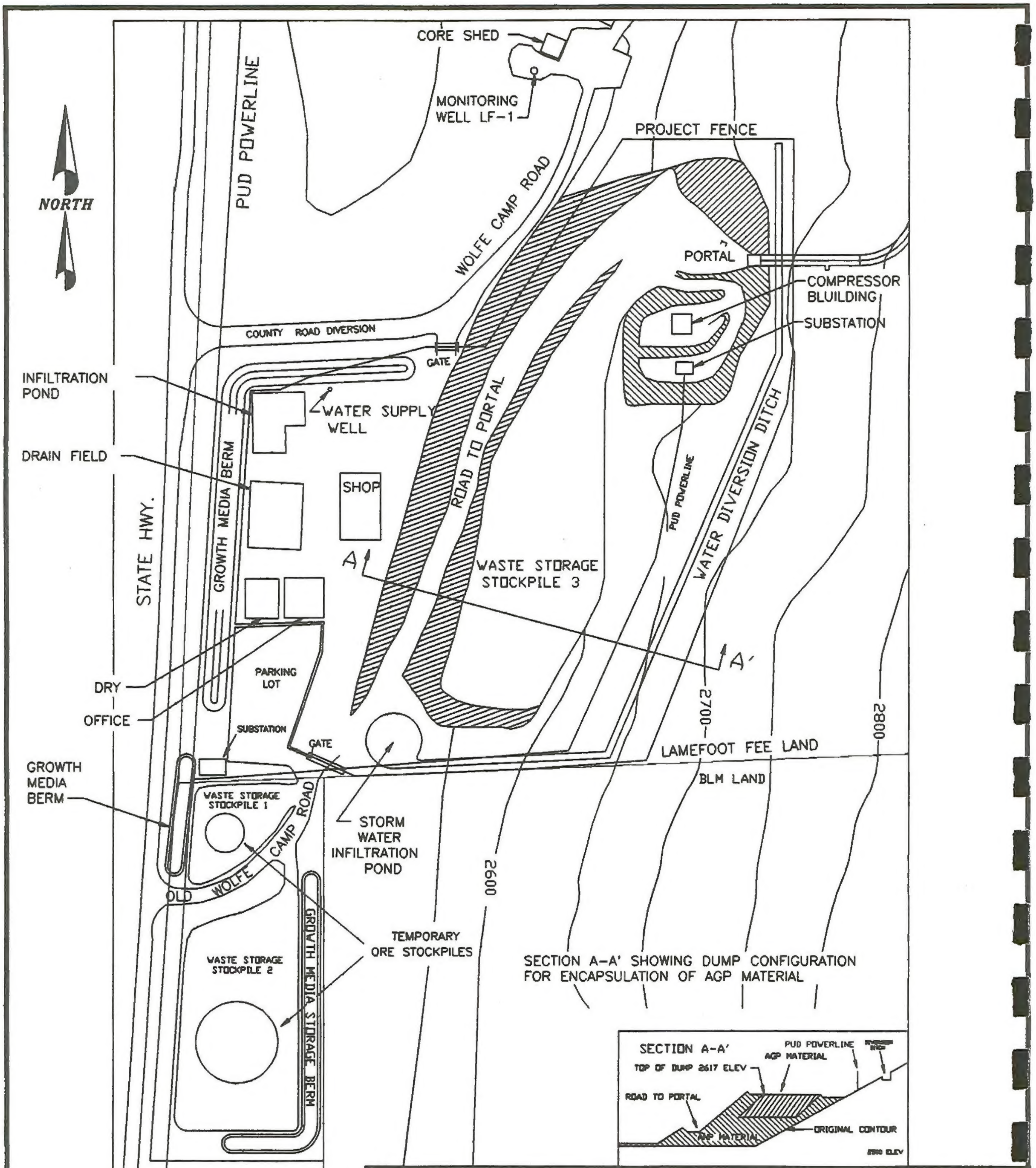
In general, the disturbance areas have been cleared and stripped of coversoil. The coversoil was stockpiled, and the locations have been selected to protect the coversoil resource by minimizing wind and water erosion and facilitating later reclamation activities. The coversoil stockpiles have been seeded to provide a stabilizing cover to minimize erosion. Upon decommissioning, stockpiled coversoil will be redistributed on the various sites prior to revegetation. The coversoil stockpile locations are shown as growth media berms on Figure E-4.

The tops of the coversoil stockpiles which parallel State Highway 21 have been planted with hybrid poplars (*Populus spp.*) to provide stabilization, and a visual and noise buffer for traffic on State Highway 21 and residents along the west side of Curlew Lake. The stockpiles have been seeded with an approved seed mix to provide interim reclamation. The trees will be removed when final reclamation is completed.

Upon final closure of the mine and completion of exploration activities, surface facilities are planned to be removed. Equipment from the site will be removed for use at other Echo Bay mines or sold in place. Remaining structures will be demolished and salvageable materials will be sold. Foundations of removed buildings will be broken up and buried in-place, in accordance with WAC 173-304 Minimum Functional Standards For Solid Waste Handling. The area will be recontoured to establish natural drainage patterns. Prior to placing coversoil, the surface will be ripped using a dozer-mounted ripper bar to a depth of 12 to 18 inches to alleviate compaction and increase infiltration. This practice will reduce runoff and erosion, provide more available moisture for plant roots, and provide a roughened contact surface for applied coversoil. After ripping, coversoil will be placed at a depth of approximately 8 inches. Coversoil will be re-spread using a bulldozer. Echo Bay has estimated that 235,000 ft^3 of coversoil are stored in the stockpiles at the surface facilities. This volume is sufficient to place approximately 8 inches of coversoil on the area occupied by surface facilities and on the estimated 2.3 acres of drill access road that will require hauling of coversoil from stockpiles at the surface facilities. Table E-1 summarizes the coversoil mass balance. It has been assumed that the former waste disposal areas will not require coversoil placement following removal of the waste rock, because these areas were only partially stripped of coversoil. Textural analysis of material from the area to the south of the southern waste area, which has been partially stripped but not covered with waste, indicates there is sufficient growth medium to support revegetation.

Following coversoil placement, the surface will be shallow-ripped along the contour to a depth of approximately 8 inches, using a chisel plow. This will create a roughened surface which provides protected micro-environments to aid in vegetation establishment. It is anticipated that a stable vegetation community can be established without fertilization. If vegetation monitoring indicates symptoms of nutrient deficiency preventing successful revegetation, Echo Bay personnel will determine fertilizer rates which will allow establishment of a low-maintenance plant community. Additional samples will be taken from all surfaces to be revegetated and coversoil stockpiles, and will be tested for available nutrients prior to coversoil placement. It is likely that nutrient conditions may differ slightly from those currently existing on the site. Care will be taken to minimize the use of nitrogen, which promotes the establishment of weedy species.

Seeding will be conducted in the fall whenever possible to take advantage of late fall and early spring moisture. Reclaimed areas will be reseeded by broadcast seeding, using the approved seed mix. Broadcast seeding provides for a more natural-appearing community than drill seeding which plants seeds in straight lines at fixed intervals and results in a linear-appearing plant community. The pre-disturbance vegetative



ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

FACILITY LAYOUT

DATE: APRIL 1993	SCALE: 1" = 200'	FIG. NO. E-4

LFDUMP1

TABLE E-1

COVERSOIL SUMMARY

Location	Available Ft^3	Required Ft^3
Sidecast and Small Stockpiles in Areas A,B,C,D,E,F AND G	104,355	104,355
Area H	0	53,550
Surface Facilities	235,000	181,450
Total	339,400	339,400

Note: Areas are shown on various figures in Lamefoot 1992.

community on this site was a bluebunch wheatgrass/Idaho fescue community. Woody species will not be planted in this area in order to allow establishment of a vegetative community similar to the pre-mining community.

4.2 WASTE ROCK DISPOSAL AREA

At the conclusion of mining, it is anticipated that most of the waste rock will be returned to the mine by backfilling the material in the underground workings. Any remaining waste rock areas on the surface will be contoured to a slope of approximately 2.5 H:1 V. The waste rock pile will be revegetated after placement of a coversoil cover.

4.3 UNDERGROUND WORKINGS

Underground workings will be reclaimed by backfilling selected areas with material from the waste rock piles and the road relocation excavation. In the case of temporary closure of the mine, a steel door will be placed at the entrance to the workings to prevent entrance. Upon ultimate abandonment of the site, the portal will be plugged, recontoured, and revegetated (Figure E-5).

Plugging of the adit will be accomplished according to the guidelines specified in the BLM Reclamation Handbook (1992b). Plugging the workings will also provide several environmental advantages, and preventing flow from the workings will allow the water table to stabilize at the pre-mining level. This will inundate some of the workings, thus minimizing oxidation of sulfide-bearing material, preventing acid drainage, and providing additional resistance to potential subsidence.

Backfilling will be the primary means of preventing subsidence of the rock overlying the slopes. This will serve the dual purpose of preventing surface damage caused by subsidence and minimizing flow into the workings by preventing fractures caused by subsidence.

The cut face of the entrance to the portal will be partially backfilled. The upper slopes will be left as benches and highwalls. Concurrent reclamation of the upper slopes is in progress and will continue. The slopes have been hydroseeded using the approved seed mix. An erosion control blanket has been placed on parts of the upper face to stabilize the surface and to provide a suitable micro-environment for revegetation.

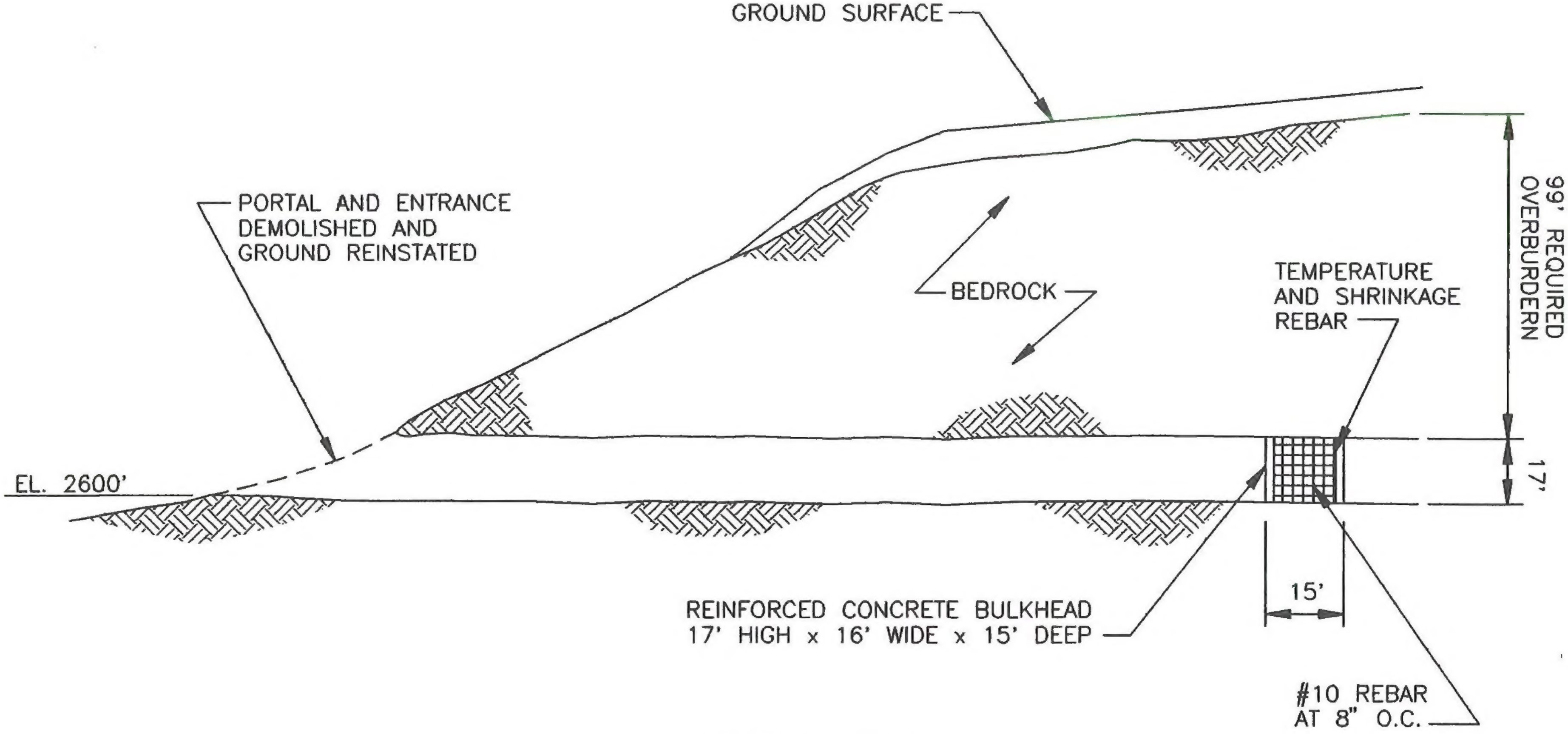
The ventilation raise at mine closure will be permanently capped. The cap will be designed to prevent subsidence at the surface even in the event of collapse of the raise walls. As shown on Figure E-6, the cap will be constructed of reinforced concrete. Figures E-7, E-8, and E-9 present conceptual designs for permanent closure of the other adits at the Lamefoot Mine.

4.4 SEDIMENT CONTROL STRUCTURES

The diversion ditches are being reclaimed concurrently by revegetating with the approved seed mix. Vegetation will reduce sediment by stabilizing the sideslopes of the ditches and by reducing the velocity of flows in the ditch.

4.5 KEY MILL SITE

The Key Mill and tailings impoundment will be reclaimed as previously described, and as permitted in the Kettle River Project Final Environmental Impact Statement (DOE 1988). This site is on private land and was permitted by the Washington DOE.


GROUND SURFACE
PORTAL AND ENTRANCE DEMOLISHED AND GROUND REINSTATED
BEDROCK
TEMPERATURE AND SHRINKAGE REBAR
99' REQUIRED OVERBURDERN
EL. 2600'
17'
15'
REINFORCED CONCRETE BULKHEAD 17' HIGH x 16' WIDE x 15' DEEP
#10 REBAR AT 8" O.C.

SIDE VIEW

SCALE: 1" = 50'

NOTES:

1. MAXIMUM HEAD (FT.) 530
2. LINE OF SIGHT DISTANCES FOR ESTIMATING MAXIMUM EARTHQUAKE LOADING APPROXIMATE, BUT CONSERVATIVE. ALL CONCRETE TO BE 3000 PSI COMPRESSIVE STRENGTH.

ECHO BAY LAMEFOOT PROJECT

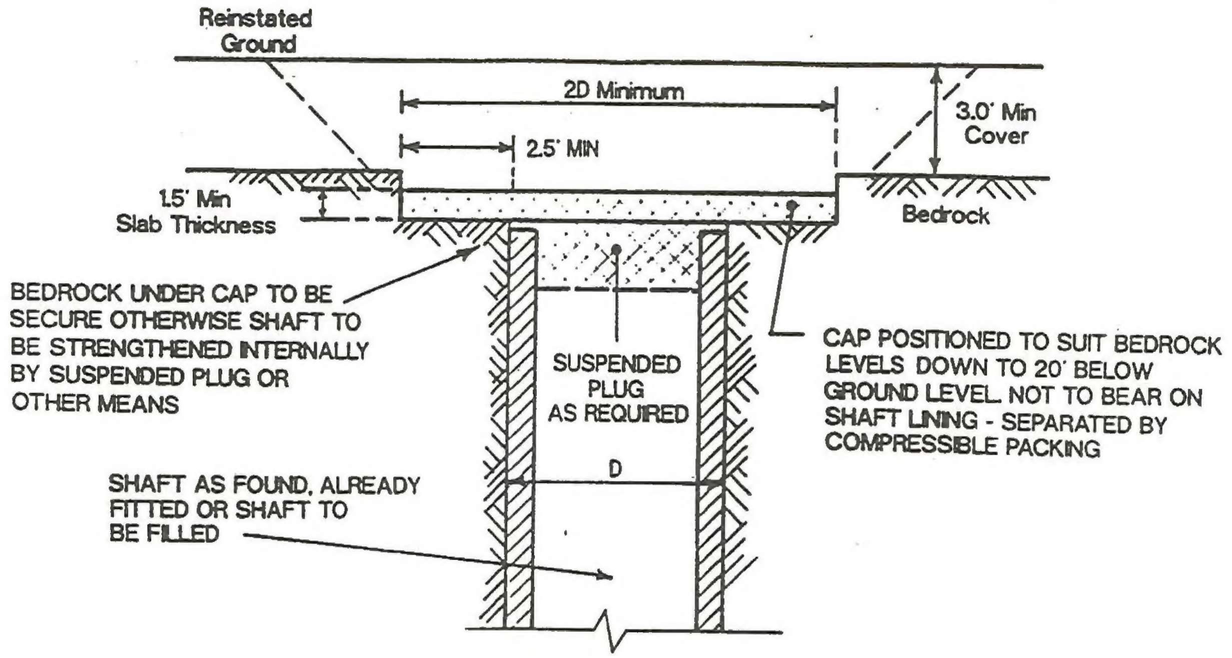
SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

CONCEPTUAL DIAGRAM OF PORTAL #1 ADIT CLOSURE

DATE: MAY 1994 | SCALE: 1" = 50' | FIG. NO. E-5

ECHOBAY2


Reinstated Ground
2D Minimum
3.0' Min Cover
2.5' MIN
1.5' Min Slab Thickness
Bedrock
BEDROCK UNDER CAP TO BE SECURE OTHERWISE SHAFT TO BE STRENGTHENED INTERNALLY BY SUSPENDED PLUG OR OTHER MEANS
SUSPENDED PLUG AS REQUIRED
CAP POSITIONED TO SUIT BEDROCK LEVELS DOWN TO 20' BELOW GROUND LEVEL. NOT TO BEAR ON SHAFT LINING - SEPARATED BY COMPRESSIBLE PACKING
D
SHAFT AS FOUND, ALREADY FITTED OR SHAFT TO BE FILLED

NOTES:
- CAP DESIGNED FOR OVERBURDEN PLUS SUPERIMPOSED LOAD OF 700 Lbs./Ft.^{2}
- REINFORCED CONCRETE SLAB STRENGTH 4350 psi. CONCRETE MINIMUM THICKNESS 1.5'
- REINFORCING BARS TO BE NOT LESS THAN 1 5/8" DIAMETER AND TO HAVE NOT LESS THAN 4 INCHES COVER.
- CAP TO BE MARKED WITH SHAFT REFERENCE NUMBER, DIAMETER AND DEPTH, AND POSITION OF SHAFT CENTER.

SOURCE: BLM SOLID MINERALS RECLAMATION HANDBOOK, 1992, Figure IX-8

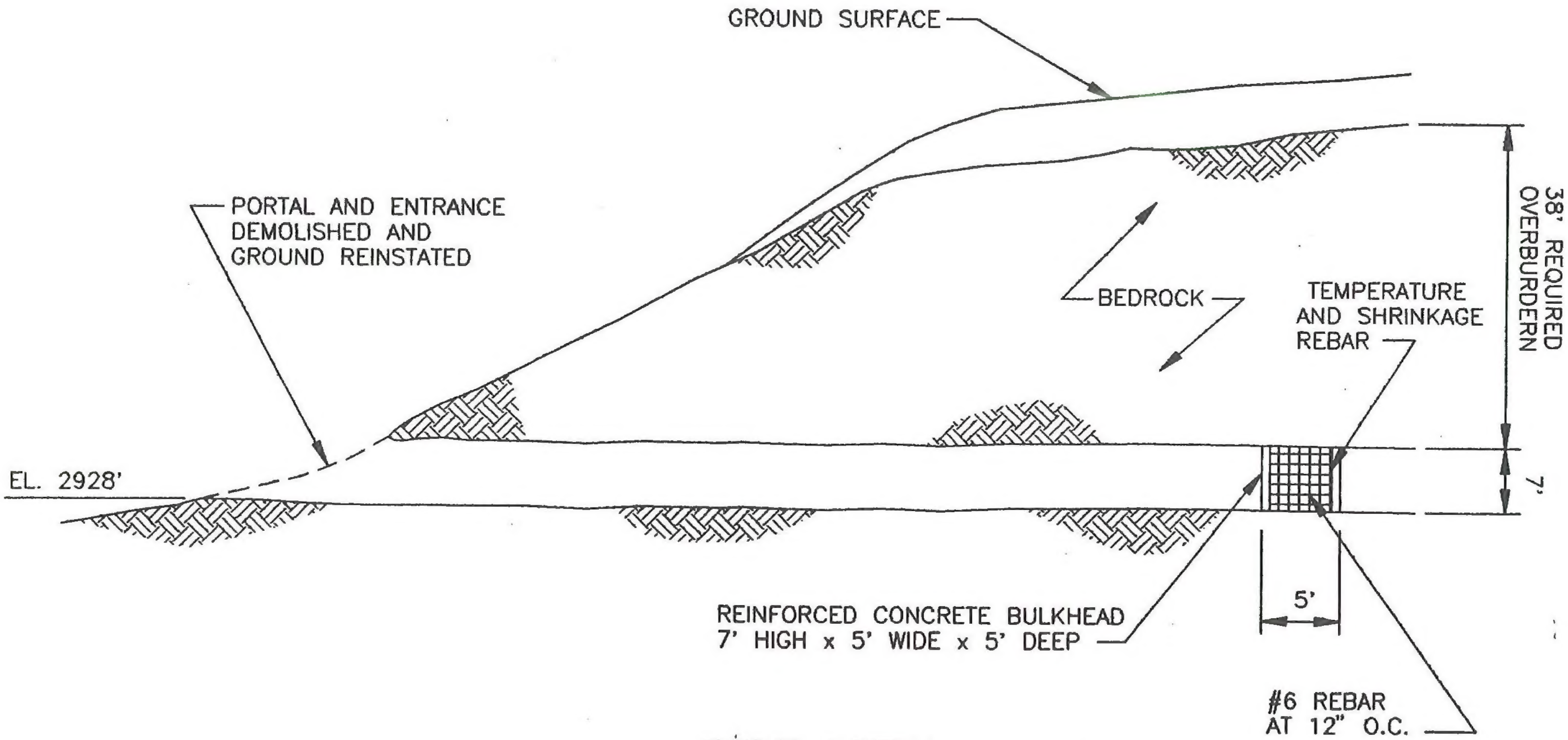
ECHO BAY LAMEFOOT PROJECT
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

CONCEPTUAL DIAGRAM OF PERMANENT SHAFT CLOSURE

DATE: APRIL 1993 | SCALE: 1" = 200' | FIG. NO. E-6

EB


GROUND SURFACE
PORTAL AND ENTRANCE DEMOLISHED AND GROUND REINSTATED
BEDROCK
TEMPERATURE AND SHRINKAGE REBAR
38' REQUIRED OVERBURDERN
EL. 2928'
7'
5'
REINFORCED CONCRETE BULKHEAD 7' HIGH x 5' WIDE x 5' DEEP
#6 REBAR AT 12" O.C.

SIDE VIEW

NOT TO SCALE

NOTES:

1. MAXIMUM HEAD (FT.) 202
2. LINE OF SIGHT DISTANCES FOR ESTIMATING MAXIMUM EARTHQUAKE LOADING APPROXIMATE, BUT CONSERVATIVE. ALL CONCRETE TO BE 3000 PSI COMPRESSIVE STRENGTH.

ECHO BAY LAMEFOOT PROJECT

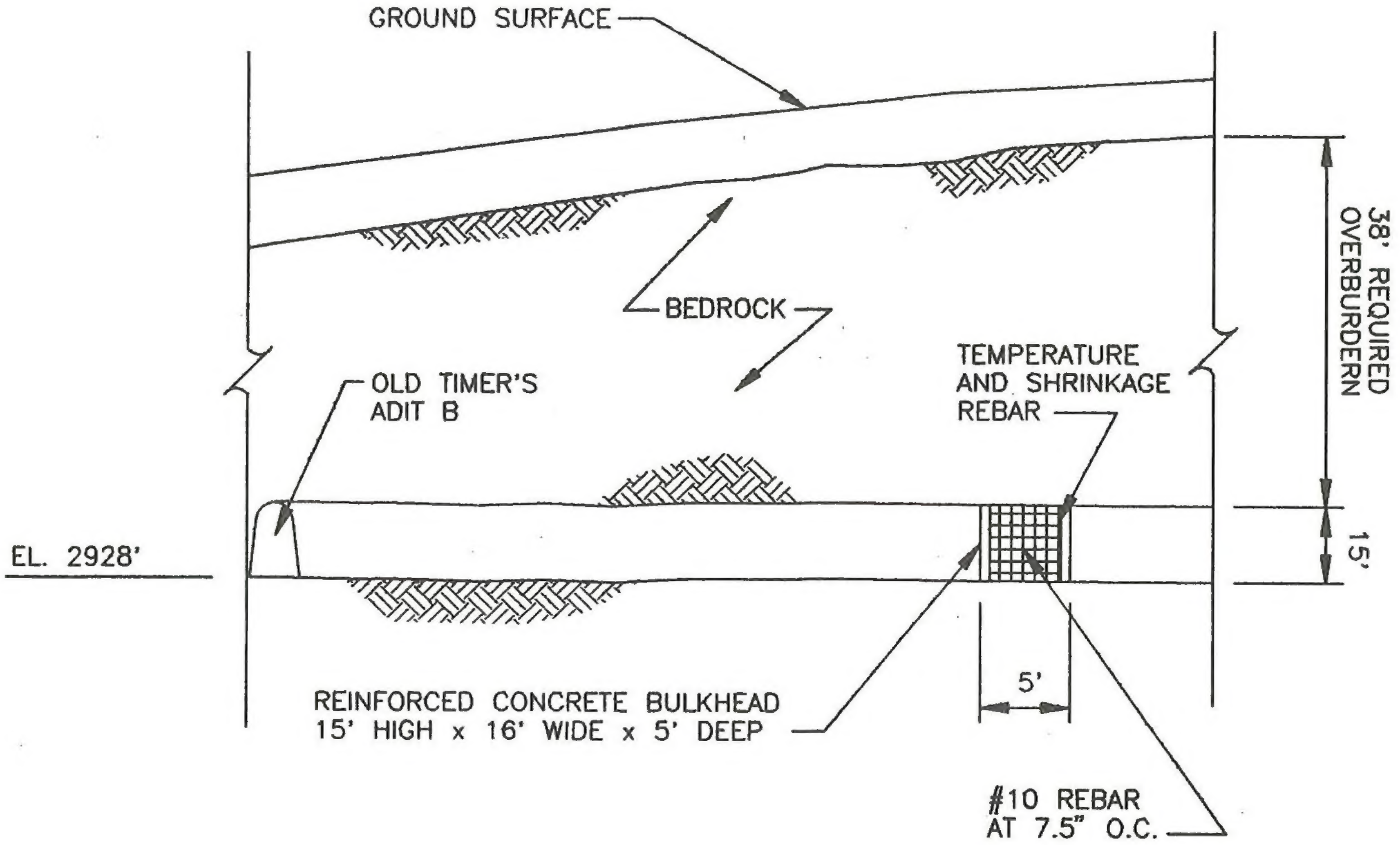
SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

CONCEPTUAL DIAGRAM OF OLD TIMER'S ADIT A CLOSURE

DATE: MAY 1994 | SCALE: N.T.S. | FIG. NO. E-7

ECOBAY3B



SIDE VIEW

NOT TO SCALE

NOTES:

1. MAXIMUM HEAD (FT.) 202
2. LINE OF SIGHT DISTANCES FOR ESTIMATING MAXIMUM EARTHQUAKE LOADING APPROXIMATE, BUT CONSERVATIVE. ALL CONCRETE TO BE 3000 PSI COMPRESSIVE STRENGTH.

ECHO BAY LAMEFOOT PROJECT

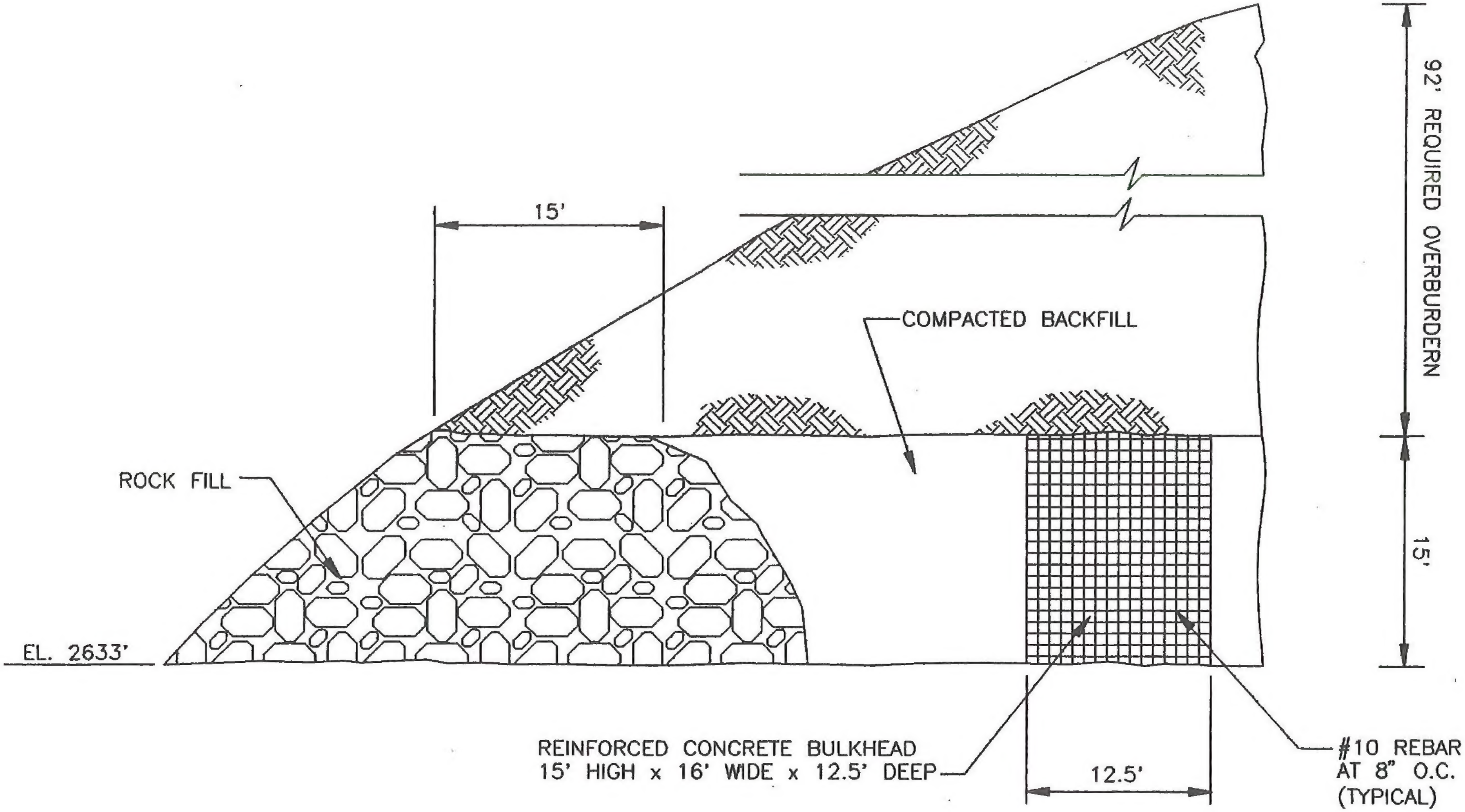
SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

CONCEPTUAL DIAGRAM OF OLD TIMER'S ADIT B CLOSURE

DATE: MAY 1994 | SCALE: N.T.S. | FIG. NO. [illegible]

ECOBAY3A



SIDE VIEW

SCALE: 1" = 10'

NOTES:

1. MAXIMUM HEAD (FT.) 497
2. LINE OF SIGHT DISTANCES FOR ESTIMATING MAXIMUM EARTHQUAKE LOADING APPROXIMATE, BUT CONSERVATIVE. ALL CONCRETE TO BE 3000 PSI COMPRESSIVE STRENGTH.

ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

CONCEPTUAL DIAGRAM OF BACKFILL CROSS CUT CLOSURE

DATE: MAY 1994	SCALE: 1" = 10'	FIG. NO. E-9

ECHOBAY1

5.0 TEMPORARY CLOSURE PLAN

Although the proposed project will operate year round, it is possible that conditions may be encountered during the life of the project that may require temporary shutdown of the operations. The primary concern during a temporary closure will be maintenance of the water control structures. Because of the substantial investment Echo Bay will have in the facility, it will be staffed during any shutdown.

The temporary closure plan is based on an economic condition shutdown of more than one year's duration. The following steps will be followed to ensure that the closure and subsequent startup activities will be accomplished in a timely and environmentally safe manner:

- In the event of a temporary shutdown planned for more than one year, the appropriate regulatory officials in the BLM and Washington DOE will be promptly notified. Reclamation activities will proceed if the temporary shutdown exceeds more than 6 years.

- Inventories of petroleum products, and explosive or other potentially hazardous supplies that will not be used during shutdown will be used at other sites, returned to suppliers, or disposed of in compliance with the appropriate regulations.

- Echo Bay personnel will regularly inspect on-site shutdown monitoring and maintenance activities, including:

    - Maintaining access roads to all project facilities and monitoring locations

    - Maintaining diversion ditches and other facilities in preparation for snowmelt

    - Security and fire patrol of the facilities

- Monitoring inspection reports will be completed and submitted to appropriate state and federal regulatory agencies during the temporary closure period, as required.

6.0 POST-CLOSURE MONITORING

6.1 SUBSIDENCE

During mining, the stopewalls and surface will be monitored for signs of subsidence. The results of this monitoring will be used to determine the placement of backfill during final reclamation.

The surface will be visually monitored annually for a five-year period following mining to determine whether there is evidence of surface subsidence associated with the underground workings. Backfilling of the underground workings should prevent subsidence; however, in the unlikely event that subsidence is observed, Echo Bay will consult with the appropriate agencies to determine mitigation measures.

6.2 ACID GENERATION

Details for monitoring for acid drainage are discussed in Section 2.3.5 and Section 4.3 of the FEIS.

6.3 REVEGETATION MONITORING PLAN

The reclaimed private and BLM land will be visually inspected by qualified Echo Bay personnel to verify that revegetation is adequate to provide the post-mining land use of wildlife habitat. Following mine closure, inspections will be performed annually for a minimum of three years during the peak growing season until a satisfactory vegetative community has been established on all reclaimed lands. Criteria for a satisfactory vegetative community will be the achievement of 75 percent of cover and an average species diversity of 35 to 40 percent for a reference community to be selected with concurrence of the BLM. Echo Bay will monitor both the private and BLM land, and will repair any areas where revegetation is not successful or where excessive soil erosion is evident.

7.0 PUBLIC SAFETY

Various activities prior to and during the mine life and closures will be and have been performed to protect public safety. Most of these measures have been discussed in the main body of the POO. These measures include:

- Temporary stabilization of talus slopes above the old Wolfe Camp Road alignment by removing large boulders and netting the remaining material with chain link.
- Relocation of the Wolfe Camp Road junction with State Highway 21 to avoid traffic conflicts between the public and mine equipment.
- Prevention of potential public safety hazards associated with talus slopes above the old Wolfe Camp Road alignment by relocating the road to the opposite side of the drainage.
- Closure of underground workings by backfilling and plugging the portal, the exhaust cross-cut portal, and the ventilation shaft by constructing blockages at the entrances, as well as covering by backfilling to return the surfaces to approximate pre-mining contours.
- Recontour middle exploration road and upper road as a ditch (Area H).

8.0 NOXIOUS WEED CONTROL PLAN

Reclamation will take place as soon as possible after disturbance, using a seed mixture which will include species that establish quickly. This will help prevent the establishment of noxious weed species. Only certified noxious weed-free species will be used in reclamation. Minimizing the use of fertilization will also prevent the establishment of noxious weed species which prefer high nitrogen levels in soil.

A list of noxious weeds that may appear on the Lamefoot site is presented in Table E-2. The noxious weed control plan will include the application of appropriate herbicides. Herbicide technology for the control of weeds has developed rapidly in recent years, and is the most widely used means of removing noxious weeds from naturally-occurring plant communities. The use of herbicides has many advantages over other control methods (including biological, mechanical, and fire methods). These advantages include:

- Less expensive than most mechanical methods
- Can be used on steep or rocky slopes where mechanical methods are not possible
- Provides a selective means of killing certain weed species, such as root sprouters that cannot be efficiently controlled by other methods
- Maintains grass and litter cover, and does not expose soil to erosion
- Provides rapid control

TABLE E-2

FERRY COUNTY NOXIOUS WEED LIST

"B" Designate		
Tansy Ragwort	Scotch Thistle	Yellow Starthistle
Leafy Spurge	Rush Skeletonweed	Spotted Knapweed
Scotch Broom	Common Bugloss	Common Catscar
Oxeye Daisy	Orange Hawkweed	Yellow Hawkweed
Black Knapweed	Brown Knapweed	Meadow Knapweed
Plumeless Thistle		
Russian Knapweed (in north half of country)	Diffuse Knapweed is a "B" designate on vehicle corridors, buffer strips, and in areas of limited distribution.	
Class "B" or "C"		
Field Blindweed	Eurasian Watermilfoil	Houndstounge
Knapweed Complex	St. Jonswort	Canada Thistle
Yellow Toadflax	Dalmation Toadflax	Black Henbane
Poison Hemlock	Baby's Breath	Absinth Wormwood
Western Waterhemlock	Whitetop (Hoary Cress)	Jointed Goatgrass
Musk Thistle	Puncturevine	

- Is safer than fire

The plant species proposed for revegetating all facilities include a mixture of grasses and forbs. The herbicides which are proposed for controlling all noxious weeds that may invade revegetated areas are 2,4-D and Tordon. These herbicides, when properly applied, will not damage grasses, but will affect broadleaf plants such as forbs and shrubs. Annual weed inspections and treatments will keep establishment of these species to a minimum and provide adequate control.

The use of herbicides on federal land must be approved by the BLM. Echo Bay will consult with the BLM to determine the most appropriate herbicide.

9.0 UNDERGROUND RECLAMATION

Reclamation of underground workings by backfilling, plugging, and capping, will minimize surface subsidence and the potential for acid drainage, and will allow the groundwater levels to return to an approximate pre-mining level. Bulkheads will be required to prevent groundwater that enters the Lamefoot Mine from bypassing through the mine workings, to impound the water entering the Lamefoot Mine, and to reestablish approximate pre-mining groundwater conditions upon ultimate abandonment of the site. Closures will also be required to prevent human access to near-surface mine openings when the site is abandoned.

The goal of bulkhead construction is to eliminate the potential point sources for mine drainage at the mine portals and, thereby, to return groundwater entering the mine to the groundwater flow regime. The resulting mine pool will be in contact with limestone which should buffer the impounded mine water and reduce the oxygen available for the oxidation of sulfide minerals exposed in stope walls and in some of the backfill. Appendix I presents the design calculations for the underground bulkheads. Four bulkheads will be required to impound water that enters the mine, moves through low-resistance flow paths, and exits the access adit portal during the operating period. One bulkhead will be required in the access adit (Figure E-5), one in the backfill adit (Figure E-9), and one in each of the two the old prospect adits (Figures E-7 and E-8) that provide exhaust ventilation near the top of the mountain. The access adit bulkhead must be constructed at a sufficient distance from the portal to eliminate any potential for either chimney collapse to the surface or hydrofracture of the adit walls. The backfill adit bulkhead must be constructed east of Wolfe Camp Road, where sufficient cover will be present to eliminate any potential for either chimney collapse to the surface or hydrofracture of the adit walls. An exhaust-ventilation adit bulkhead will only be required if its elevation is below that of the highest elevation in the mine stopes, and could result in impounded water being forced out of that portal.

Bulkhead design to prevent point-source release of water impounded in the mine pool would be based on the potential head, opening dimensions, hydraulic pressure gradient, concrete shear stress, rock shear stress, one-way beam bending, hydrofracture potential, and potential chimney collapse height. The recommended closure design method is the American Concrete Institute, Building Code Requirements for reinforced concrete (ACI 318-89 rev 1992) plus hydrofracture potential (Einarson & Abel 1990). All of the bulkheads are overdesigned for 1.56 to 2.15 times the maximum possible head. This method has been successfully used during construction of the two acid-mine drainage bulkheads at the Summitville Mine in Southern Colorado (under EPA controls), two bulkheads at the Comet claims above Silverton, Colorado (under Colorado Division of Minerals and Geology control), 14 bulkheads west of Redding, California (under California Department of Water Quality control), two bulkheads at the Sunnyside Mine at Gladstone, Colorado (under Colorado Division of Minerals and Geology control), and elsewhere. Calculations for the design of bulkheads at the Lamefoot Mine are presented in Appendix I of the Plan of Operations.

Adit and shaft closures are safety measures to prevent access to the mine workings after closure of the mine, and are designed to resist hydraulic pressure. Shaft closures will be required over the top of the ventilation shaft east of Wolfe Camp Road, and over the top of the cemented and uncemented waste backfill shafts in the quarry west of Wolfe Camp Road. An adit closure will be required at the portal of the access adit to prevent human access to the Lamefoot Mine between the portal and the bulkhead in the access adit. A closure is recommended for the prospect adit only in the case where no bulkhead is constructed at that location. If a closure is installed in the prospect adit, it should be placed well inside the portal to maintain the approximate conditions present before the Lamefoot Mine exploration program.

10.0 BACKFILL QUARRY RECLAMATION (ADAPTED FROM GOLDER ASSOCIATES 1994)

It is Echo Bay's intent to reclaim the pit and haul roads following the completion of mining operations. The various aspects of the reclamation plan are addressed in the following sections.

10.1 TIMBER HARVEST AND SITE CLEARING

Prior to the commencement of clearing and mining activities, any timber within the quarry perimeter will be logged as described in Section 3.1.

10.2 COVERSOIL STRIPPING AND SALVAGE

Once the timber harvesting activities have been completed, coversoil will be stripped from within the pit perimeter and stockpiled for later use in reclamation.

Where practical, stockpiles will not exceed 30 feet in height in order to decrease wind erosion and compaction. Stockpile side slopes will not exceed 2 H:1 V in order to reduce wind and water erosion, and to enhance the growth of protective vegetation cover. The stockpiles will be seeded with the temporary seed mixture for private land as detailed in Section 1.1.

10.3 QUARRY

The objective of the reclamation efforts for the quarry will be to ensure long-term overall stability of the walls. At the completion of mining, the configuration of the quarry will consist of 25-foot-high benches separated by catch-berms of varying widths. The catch-berms are intended to retain any ravelling or sloughing debris. The overall wall slopes will vary from 37 to 45 degrees, and the maximum height of the slopes will be approximately 125 feet.

Catch-benches will be constructed to ensure the surface will have an inclination toward the wall of the pit so moisture can be retained on the catch-bench for the purpose of revegetation. Approximately 8 inches of coversoil will be placed on the catch-berms during mining to the extent practical, in order to enhance revegetation of the slopes following the completion of mining. The benches will be revegetated with grasses and shrubs as described in Section 2.6.2 for private land.

Public safety on the relocated county road will be achieved by preservation of the benches in the quarry and adequate set-back of the highwall to at least 50 feet. However, the layout of the location of the blast holes will be designed so the benches will have a sinuous outline in plan view. (The exact outline of the benches will be finalized through the surface mining permit process, and the diagrams of the quarry are conceptual. The quarry configuration has been designed with the Division of Natural Resources and the County Engineer in accordance with their guidelines and will be approved by the County Commissioners.) Berms approximately 6 feet high with 1.5 H:1 V side slopes will be constructed, where possible, around the perimeter of the quarry about 30 feet back from the edge. In areas where site topography precludes the construction of rock berms, appropriate weather-resistant warning signs will be posted at regular intervals stating "Warning Steep Slopes Ahead." Any roads that are intersected by the quarry cut will be blocked by earth berms to prevent occasional ORVs from driving over the highwall.

10.4 COUNTY ROAD RELOCATION

A primitive county road that is used by local residents is located along the east side of the valley. The development of exploration roads on the slope above the road has resulted in slope instability. Following the completion of mining operations, Echo Bay proposes to relocate the county road along the in-pit haul road alignment that will be established along the east edge of the pit floor. The location of the haul road alignment is shown in Figure E-10 and detailed plan and profile views of the relocated county road are shown in Figures E-10a, E-10b, E-10c, and E-10d.

The old county road may be used as a pad for a post-closure monitoring, in which case a gate will be used to permanently close off the road. Otherwise, access to the old county road will be cut off by placing berms across the intersections of the old road and the new road.

10.5 CLOSURE CRITERIA

Echo Bay will cover the benches with top soil and revegatate them concurrently with operations. Immediately following the end of operations, Echo Bay will transfer the operating permit to Ferry County.

11.0 REFERENCES

Echo Bay (See Echo Bay Minerals, Inc.)

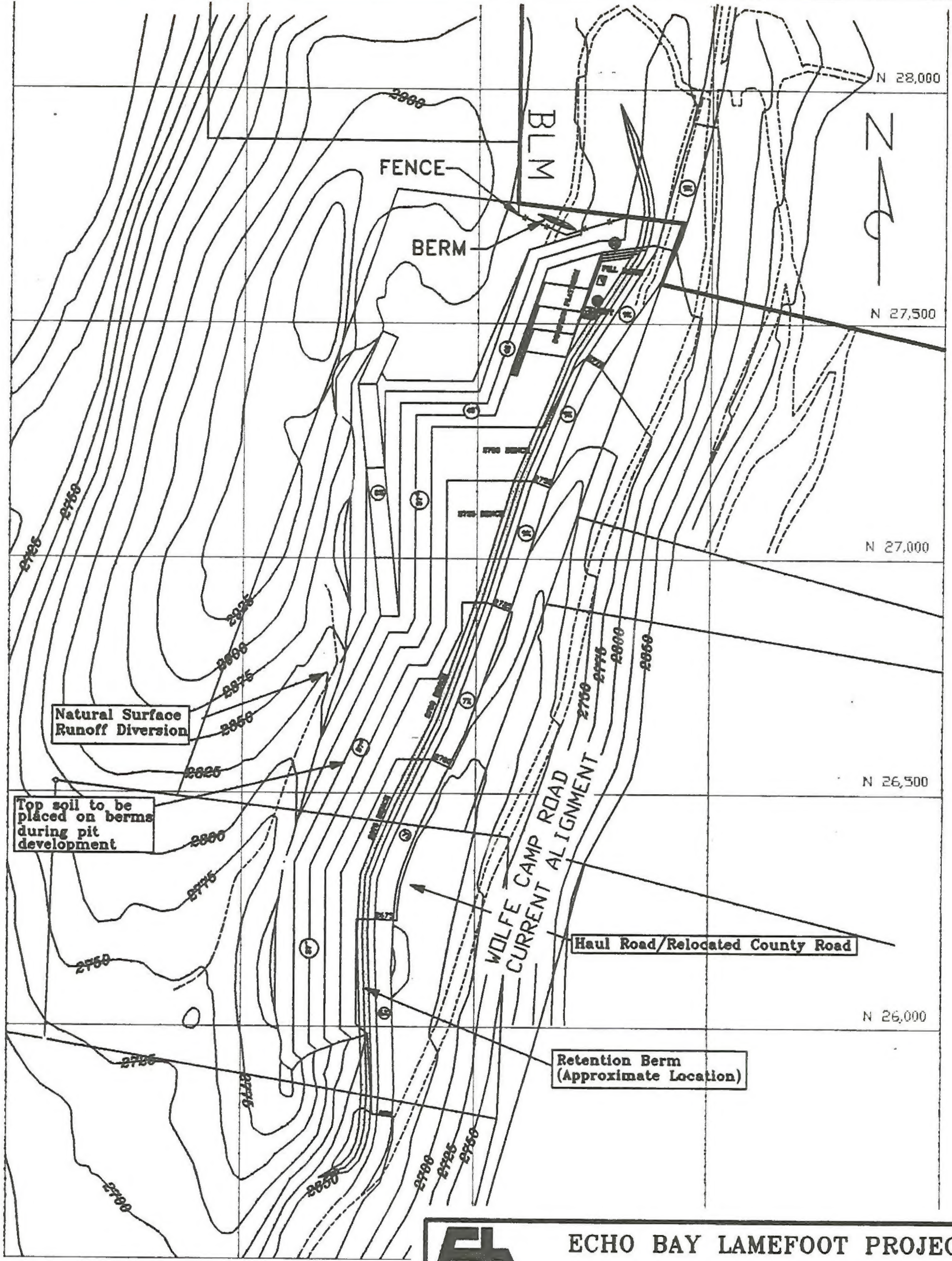
Echo Bay Minerals, Inc. 1992. Plan of Operations, Lamefoot Project. As amended 1993, 1994.

Soltanpour, P.N., R.H. Follett, and D.G. Westfall. 1985. Guide to Fertilizer Recommendations in Colorado: Soil Analysis and Computer Process. Cooperative Extension Service, Colorado State University.

Sate of Washington Department of Ecology (DOE). 1988. Final Environmental Impact Statement, Kettle River Project.

U.S. Bureau of Land Management (BLM). 1992. Solid Minerals Reclamation Handbook. BLM Manual Handbook H-3042-1. February.

U.S. Bureau of Land Management (BLM). 1985. Final Spokane Resource Management Plan/EIS. Spokane District Office, Spokane, Washington. August.


FENCE
BERM
BLM
N
N 28,000
N 27,500
N 27,000
N 26,500
N 26,000
2900
2725
2750
2825
2800
2875
2850
2825
2800
2775
2750
2725
2775
2700
2650
2700
2725
2750
2750
2775
2800
2850
Natural Surface Runoff Diversion
Top soil to be placed on berms during pit development
WOLFE CAMP ROAD CURRENT ALIGNMENT
Haul Road/Relocated County Road
Retention Berm (Approximate Location)

ECHO BAY LAMEFOOT PROJECT

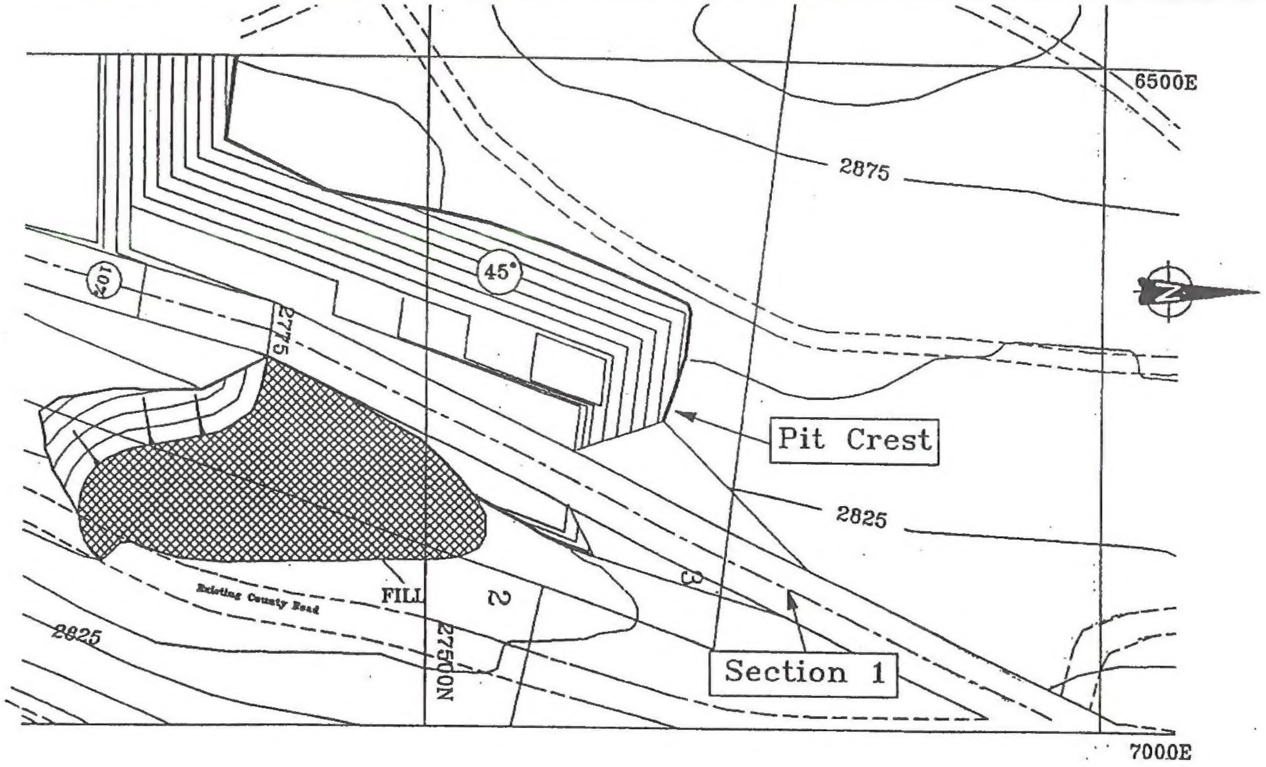
SOURCE: ECHO BAY 1993

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

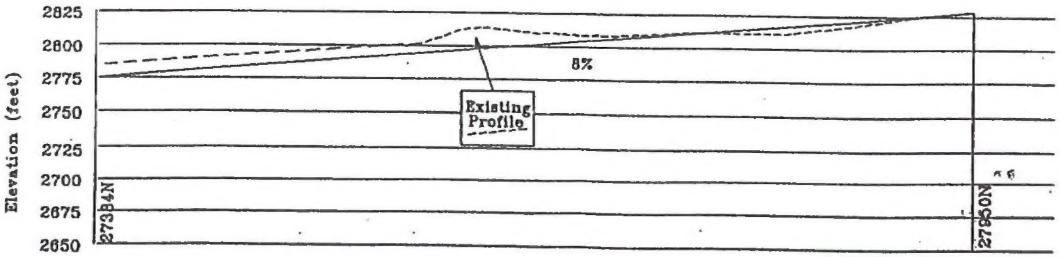
BACKFILL QUARRY AND COUNTY ROAD DIVERSION

DATE: APRIL 1994 | SCALE: 1" = 300' | FIG. NO. E-10

RBQUARRY



Section 1



Scale 1"=100'

ECHO BAY LAMEFOOT PROJECT

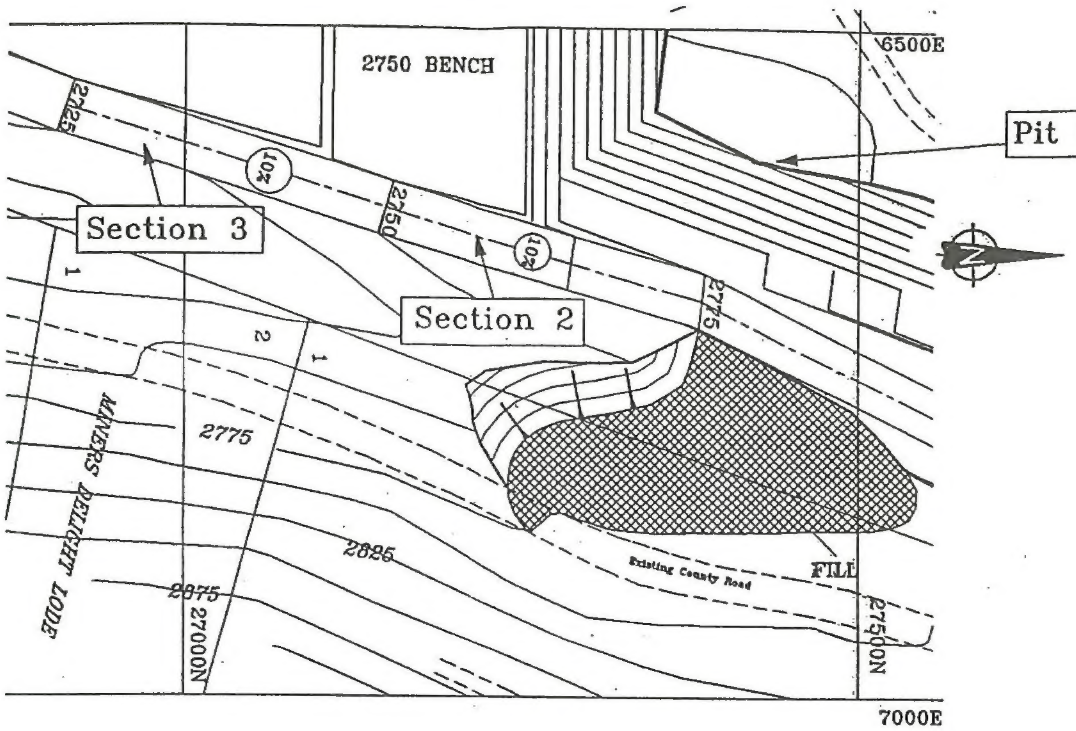
SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

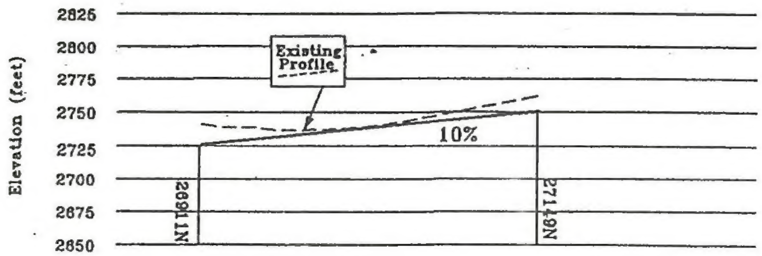
RELOCATED COUNTY ROAD SECTION 1 PLAN & PROFILE

DATE: JUNE 1994	SCALE	FIG. NO. E-10a

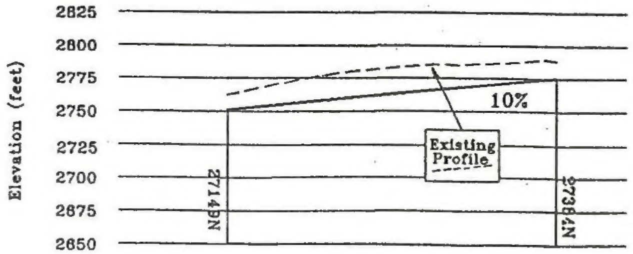
EB1



Section 3



Section 2



Scale 1"=100'

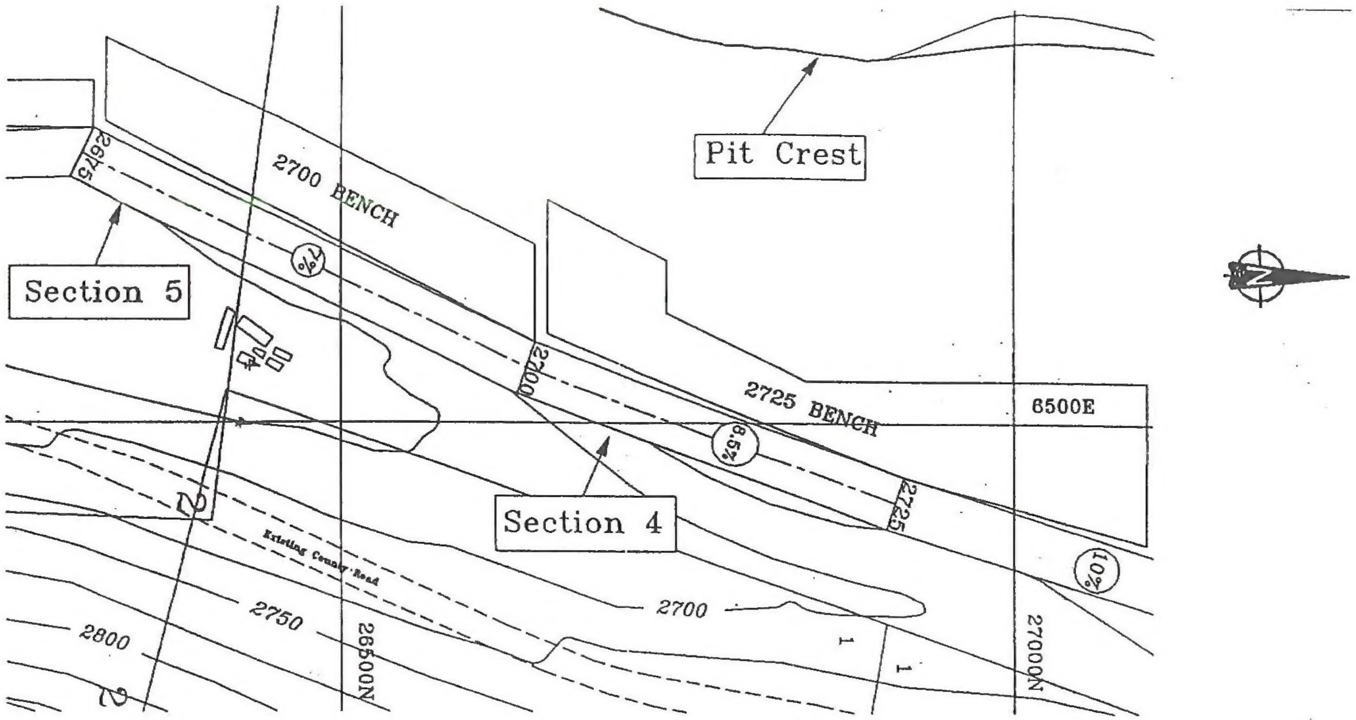
ECHO BAY LAMEFOOT PROJECT
SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

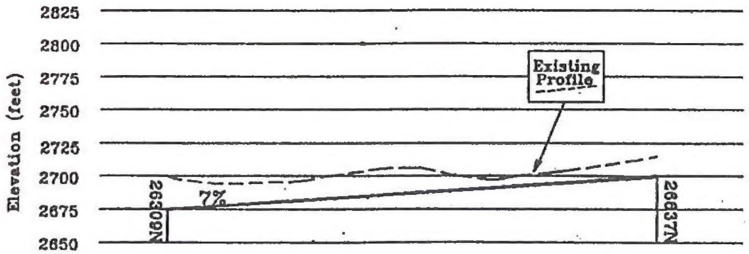
RELOCATED COUNTY ROAD SECTIONS 2 & 3 PLAN & PROFILE

DATE: JUNE 1994 | SCALE: | FIG. NO. E-10b

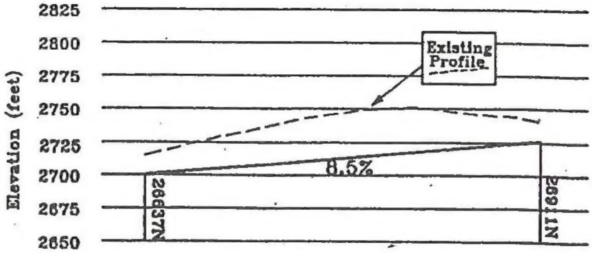
EB1



Section 5



Section 4



Scale 1"=100'

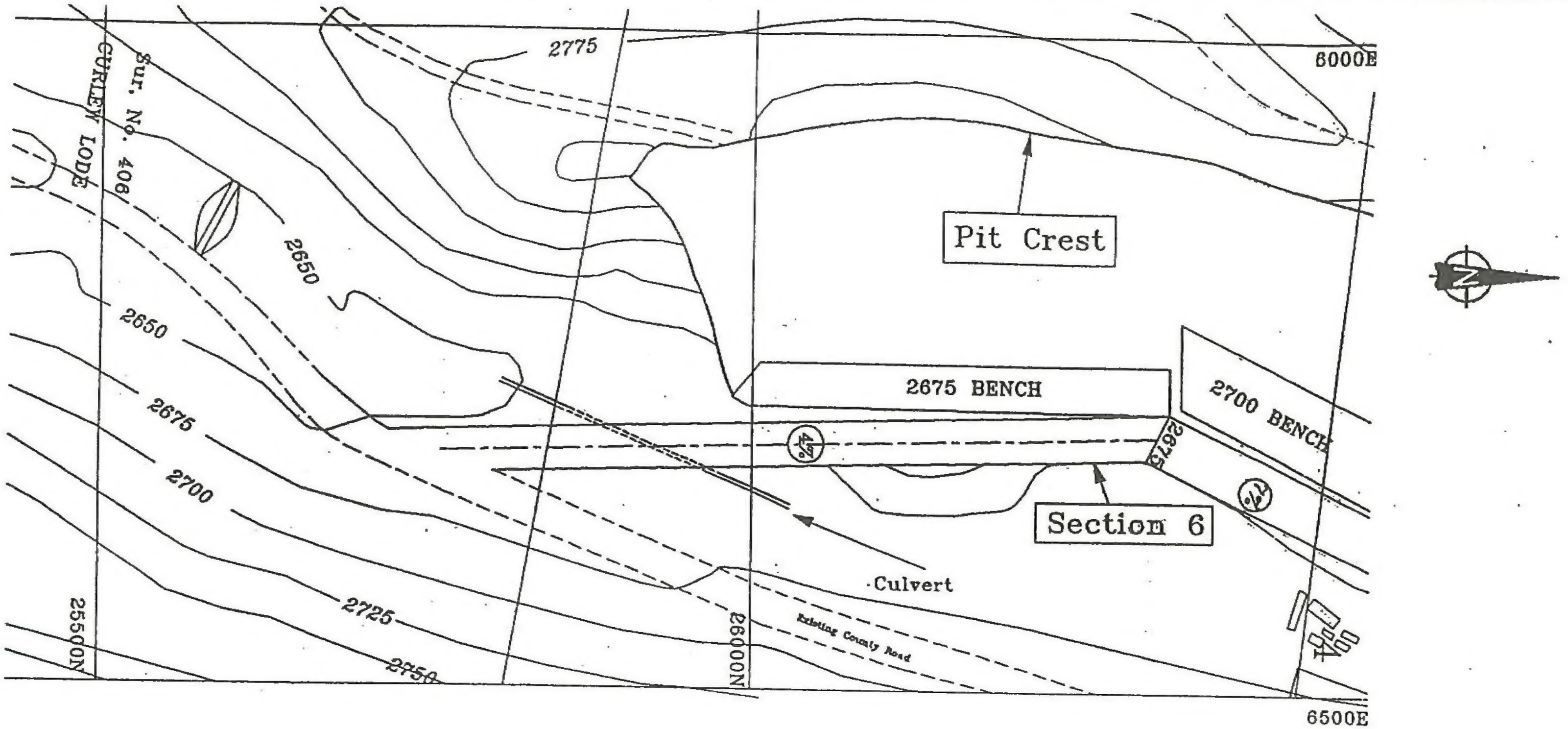
ECHO BAY LAMEFOOT PROJECT
SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

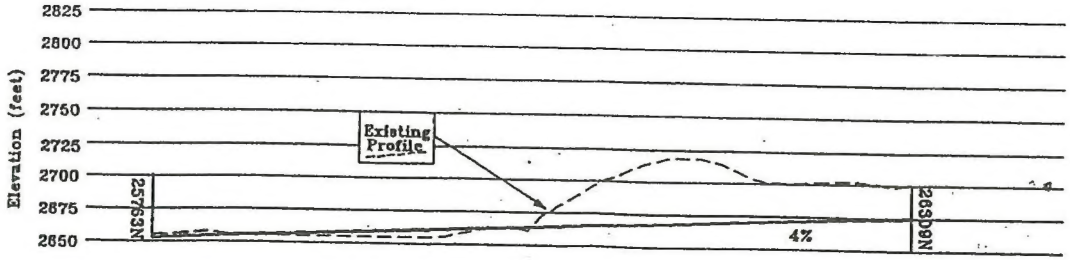
RELOCATED COUNTY ROAD
SECTIONS 4 & 5
PLAN & PROFILE

DATE: JUNE 1994
SCALE:
FIG. NO. E-10c

EB1



Section 6



BLM LIBRARY
RS 150A BLDG. 50
DENVER FEDERAL CENTER
P.O. BOX 25047
DENVER, CO 80225

ECHO BAY LAMEFOOT PROJECT

SOURCE: GOLDER 1992a

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

RELOCATED COUNTY ROAD SECTION 6 PLAN & PROFILE

DATE: JUNE 1994
SCALE:
FIG. NO. E-10d

EB1

TN 413 .W2 S65 1994

Final Lamefoot Mine
environmental impact

BLM LIBRARY
RS 150A BLDG. 50
DENVER FEDERAL CENTER
P.O. BOX 25047
DENVER, CO 80225